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ORIGINAL ARTICLES.

I.—American Jurassic Mammals.

By Professor O. C. Marsh, M.A., LL.D., F.G.S.

(PLATES VI. and VII.)

In previous publications the writer has announced the discovery of Jurassic Mammals in America, and has given brief descriptions of the more important forms brought to light.[1] Since the last article on this subject, a large amount of new material has been secured, including representatives of several hundred individuals. The remains consist not of lower jaws alone, but of various portions of the skull, and not a few vertebræ, limb bones, and other parts of the skeleton.

These fossils, although fragmentary, are usually well preserved, but owing to the peculiar conditions under which they were entombed, no two bones of the skeleton are as a rule found together. This fact, taken in connection with the very diminutive size of the animals themselves, and especially with the present brittle nature of the teeth and jaws, has rendered their investigation a work of great difficulty. The importance of the subject, however, and the fact that all the known remains of mammals from the Jurassic of America are in the collection made by the writer, have led to a careful study of the whole material, and the results will be brought together in a Memoir now in preparation for the United States Geological Survey.

Some of the results of this investigation, and notices of several new forms recently discovered, are given below in the present article.

In connection with this work, the writer has also examined the more important specimens from the Jurassic of Europe, and, likewise, the few specimens known from the Trias, in both Europe and America.

The American Jurassic Mammals hitherto found are all from essentially the same geological horizon, in the Atlantosaurus beds, of the Upper Jurassic. The principal locality is in Wyoming, on the western slope of the Rocky Mountains, and remains of two or three hundred individuals have been obtained at this place alone. At other points in the same region, a few remains have been found. A

[1] American Journal of Science, vol. xv. p. 459, 1878; vol. xviii. pp. 60, 215, and 396, 1879; vol. xx. p. 235, 1880; vol. xxi. p. 511, 1881; and vol. xxxiii. p. 327, 1887. See, also, Proceedings British Association, Montreal Meeting, p. 734, 1884.

second locality of importance is in Colorado, about three hundred miles south of the most northern known limit of these remains.

The other vertebrate fossils from this horizon are mainly Dinosaurs, many of them of gigantic size, but some scarcely larger than the mammals. Crocodiles, Turtles, small Lizards, and Fishes, are also well represented. A single Bird (*Laopteryx*), and one small Pterodactyl, have likewise been recognized from these deposits. More recently, various bones of small, anourous amphibians (*Eobatrachus agilis*) have been found, the first detected in any Mesozoic formation.[1] The deposits are lacustrine, as shown by the fresh-water shells they contain.

In investigating these American Jurassic Mammals, it was necessary to compare them, first of all, with those from the same formation in Europe. On this subject, the elaborate memoir of Owen, on British Mesozoic Mammals, was taken as the main authority.[2]

The first specimens discovered in America proved to be very near allies of European forms, and most of those since found show a remarkable resemblance to others described by Owen. Some fragmentary specimens cannot indeed be distinguished from the English fossils, but where the remains are more complete, various differences are seen, which appear to be distinctive. A few well-marked American genera have no known representatives in Europe, while some forms found in Europe are unknown in America.

One difficulty in the investigation of the remains from the two widely-separated regions arises from the necessity of relying mainly upon figures for comparison. Again, these minute, delicate fossils are often embedded in a matrix from which they cannot be removed without great danger of injury or destruction. Hence, the jaws and teeth in many cases must be examined and described from the single side exposed. If the opposite side of a similar jaw should be shown in another specimen, the two may easily be regarded as distinct. This may also be the case where upper and lower jaws are found separately. Hence, a large amount of material becomes necessary for even a proximate correlation of the closely-related forms.

Plagiaulacidæ.

One of the first American specimens discovered resembled strongly the minute lower jaws first described by Falconer, under the name *Plagiaulax*, and since investigated by Owen, Flower, and others, whose discussion of the habits and affinities of those peculiar mammals forms a well-known chapter in the history of palæontology. Of this genus, only the lower jaws were known, and this is one reason for the wide divergence of opinion as to the nature of the animals they represent. The lower jaws found in America were regarded by the writer as indicating a distinct genus, *Ctenacodon*, two species of which he has since described.

[1] Proceedings British Association, Aberdeen Meeting, p. 1033, 1885.

[2] Monograph of the Fossil Mammalia of the Mesozoic Formations, Palæontographical Society, vol. xxiv. London, 1871.

Among the separate upper jaws found in the Jurassic of England were two or three described by Owen, under the generic name *Bolodon*, but with no suspicion that they were in any way related to *Plagiaulax*. From American deposits, also, somewhat similar jaws were obtained more recently, and as they were apparently quite distinct from *Bolodon*, they were described by the writer as representing a new genus, *Allodon*. The molar teeth in one specimen resembled those of *Plagiaulax*, and the writer in his description expressed the opinion that *Allodon* should probably be placed in the *Plagiaulacidæ*. A natural inference was that *Bolodon* was the upper jaw of *Plagiaulax*, and *Allodon*, of *Ctenacodon*. However this may be in regard to the European forms, the specimens now known make it clear that the American genera are quite distinct.

The molar teeth of *Allodon* and *Ctenacodon* are of the same general type, and it is still difficult, if not impossible, to distinguish them when detached from the jaws. The premolars, however, and especially the incisors, differ in the two genera, and when well preserved may often be separated with certainty.

Allodon.

In *Allodon*, the superior dentition on each side appears to be as follows:—Incisors 3; canine 0; premolars 5; molars 2.

The lower dentition is uncertain, but is probably the following:—Incisors 1; canine 0; premolars 4; molars 2.

The upper molar series in the type specimen of *Allodon* is well shown in Plate VI. Figures 1 and 2. The five premolars have tuberculate crowns, and all appear to be inserted by two fangs. The first and second have each one external, and two internal cones. The third premolar has a small additional cusp. These three premolars diminish in size from before backward. The next premolar, or fourth, is much larger, and has its crown flattened on the inner side. There are three tubercles on the outer border, and four on the inner margin. The fifth in the series is still larger, and has a more rounded crown. There are three lobes on the outer side, and the same number on the interior face.

The two true molars have low crowns, which are divided into an outer and inner half, by a deep-worn groove. Each half bears three low tubercules, of nearly equal size. The last molar has its longitudinal groove on a line with the inner margin of the other teeth.

The superior incisors of this genus now known are represented in the detached premaxillary of *Allodon fortis*, Plate VI. Figures 7–10. The first incisor was very small. The second was the main front tooth, much larger than the third. In the type specimen of *Allodon*, represented in Plate VI. Figures 1 and 2, no suture is visible behind the first small tooth (*a*), hence this may possibly be a weak canine instead of the third incisor. In *Allodon fortis*, Fig. 7, and also in the type of *Bolodon*, Owen, the suture between the premaxillary and maxillary is distinct.

The large second incisor of *Allodon* is a peculiar tooth, and was evidently exposed to the full wearing action of a strong lower incisor,

somewhat similar to that of a Rodent. This lower tooth has not been found in place, but the one represented in Plate VI. Figures 14 and 15, may, with considerable probability, be referred to this position. The remaining lower teeth have not been found associated with the upper jaws, but they evidently resembled those of *Ctenacodon*, in some of their most important characters.

In comparing *Allodon* with *Bolodon*, we evidently have two nearly related forms. So far as at present known, *Allodon* has three incisors instead of two, a larger number of teeth in the premolar and molar series, and likewise shows other differences of less importance.

The affinities of these peculiar mammals and the inferences in regard to their habits and food, which may be drawn from the specimens now known, will be fully discussed by the writer elsewhere.

Allodon fortis, Marsh.

The present species appears to be generically identical with the type specimen of *Allodon laticeps*, but is represented by remains of much larger size. The premaxillary shown on Plate VI. Figures 7–10, may be taken as the type specimen. A number of upper molar teeth, and the large lower incisor (Figures 14 and 15 of the same Plate), are also referred to this species.

The first incisor in this premaxillary was very small, and situated close to the median line. It is wanting in the present specimen, but its size and position are indicated in the above figures. The second incisor is large and prominent, and is the principal front tooth. It has a distinct crown, which is covered with enamel, and consists of one large main cusp, with a small posterior cone. The lower surface is much worn, evidently by an opposing lower tooth which bore directly against it, from its apex to the small posterior prominence. The sides of the crowns show no signs of wear. The third and last incisor is much smaller, and is separated from the second by a short diastema. It has a distinct crown covered with enamel, but shows no marks of attrition. It is situated a little in advance of the suture with the maxillary, shown in Figure 7, *s*, Plate VI.

A second specimen referred to this species is shown in Figures 11–13, Plate VI. It is a portion of a left upper jaw containing three premolars, apparently the first, second, and third. The first two of these have a single external cone, and two inner cones, and the second tooth is larger than the first. The third premolar is still larger, unlike the corresponding tooth in *Allodon laticeps*, and has a second exterior cone behind the main one. Above this tooth, there is a large cavity, apparently the entrance of the antorbital foramen. This is shown in Figure 11, *f*, Plate VI.

The large lower incisor which met the prominent one above is probably represented in Figures 14 and 15. This tooth is faced with enamel in front, and grew from a persistent pulp, like the incisor of a Rodent. The summit is incomplete, and hence the shape of the worn surface cannot be determined.

The specimens here described indicate that *Allodon fortis* was the

largest mammal of this group hitherto discovered in the Jurassic. In bulk, it was three or four times as large as *Allodon laticeps*, and about the size of a Rat.

The only known remains of this species are from the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

Ctenacodon.

The genus *Ctenacodon* was based upon lower jaws, one of which is represented in Plate VII. Figure 1, and others in Figures 4, 7, and 8. The single, long, pointed incisor, the four, compressed, cutting premolars, and the two, minute, tubercular molars, form together a peculiar dentition. The long, sharp incisor shows no signs of wear whatever, and hence could not be opposed to the large upper incisor of *Allodon*. Its position was close to its fellow, and the two evidently acted together, as indicated in Figure 9, Plate VII. The four premolars form a close-set series, with their upper margins on a curve, all more or less notched. Some specimens, at least, show distinct marks of wear on the outer sides of the crowns, which are sometimes worn to a uniform surface. The two small tuberculate molars are of the *Microlestes* type, with a deep longitudinal groove on the upper surface of the crowns.

The entire upper dentition of *Ctenacodon* is not known with certainty, but it probably corresponded in its main features to that of *Allodon*. A portion of the upper jaw, with typical premolars, is shown in Plate VII. Figures 2 and 3. The posterior premolars, especially the last two, show strong marks of attrition on the inner sides of the crowns, and these were opposed to the compressed premolars below, forming together a most effective apparatus for cutting.

Some of the lower jaws at present referred to *Ctenacodon* apparently show no signs of wear on the premolars, and as the large incisor is not preserved, it is impossible to say definitely that they may not pertain to *Allodon*. It is likewise quite probable that some of the lower jaws considered as *Plagiaulax* may belong with some of the specimens now known as *Bolodon*. The exact correlation of the two forms cannot be determined with certainty until the upper and lower jaws are found together in position.

Ctenacodon may be distinguished from the type of *Plagiaulax* (*P. Becklesii*) in having four premolars instead of three. The summits of these teeth alone are notched, and the sides smooth, not obliquely grooved as in *Plagiaulax*. The condyle, moreover, is separated from the angle of the jaw, not confluent with it. *Ctenacodon*, also, has the angle of the jaw not only strongly inflected, but its outer margin effected into a wide horizontal shelf, making this one of the most peculiar features of the genus.

The vertical posterior condyle in *Ctenacodon* implies a strong postglenoid process, that would confine the jaw to a vertical motion.

In *Ctenacodon*, the mental foramen is large, and situated below the middle of the diastema. The dental foramen is under the last molar, but its entrance is partially concealed by a ridge descending from the base of the tooth to the inflected border of the angle.

In none of the specimens of *Ctenacodon* preserved is there any trace of a mylohyoid groove.

Ctenacodon potens, Marsh.

A third species of *Ctenacodon*, much larger than *C. serratus*, is represented by several jaws and isolated teeth, discovered since the first species was described. The most important of these specimens, which may be taken as the type, is the right upper jaw represented in Plate VII. Figures 2 and 3. The lower jaw with incisor, figured on the same Plate, may also be referred to this species. A second lower jaw in better preservation, but without the incisor, may likewise be included, although somewhat larger in size.

The upper jaw above mentioned agrees in its general shape with that of *Allodon*. It indicates a short, broad skull, with strong, expanded, zygomatic arches. There is a small antorbital foramen, as in *Allodon*. The four premolars present increase in size from before backward. The first and second are of the *Allodon* type. The last two have strong marks of attrition on the inner surface of their crowns, as shown in Figure 2 of the same Plate. They differ from the corresponding teeth in *Allodon*, in being more compressed, and adapted to cutting.[1] There were apparently two true molars, which are wanting in the present specimen, but their position and size are similar to those of the same teeth in *Allodon*.

The left lower jaw represented in Figures 7, 8, and 9 shows that the incisor in this species was very large in size, and a most effective weapon. It grew from a persistent pulp, and its massive base extended back under the fourth premolar. The crown is oval in outline at the margin of the jaw, somewhat more compressed above, and sharply pointed at the apex. There is a shallow groove on the outer surface of the lower half of the crown, and a corresponding depression along the middle of its inner face. A careful examination shows no signs of wear on any part of the crown.

The premolars are separated from the incisor by a long diastema. The first premolar is small, without serrations, and is placed close to the second. The latter is larger, inserted by two fangs, and has the summit faintly notched. The third premolar was still larger, but is so much fractured in the present specimen that its form and dimensions are uncertain. The fourth premolar is very large, notched at the summit, and with its outer face showing distinct marks of wear.

The first true molar is small, and its crown much inclined backward. The second true molar is wanting, but its alveoli show that it was also small, and placed below the first molar.

In this species, the series of four lower premolars is placed on a curve, and acts as a single cutting blade against the compressed upper premolars. This curve is completed behind by the two molars, which have their crowns inclined outward.

The second and larger lower jaw referred to this species gives some additional characters. The third and fourth premolars show

[1] A somewhat similar tooth of *Microlestes* is figured by Owen in Mesozoic Mammals, plate i. fig. 16, Mon. Pal. Soc. vol. xxiv. 1871.

distinct traces of wear on their outer surfaces. The first true molar is placed obliquely, as in the previous specimen, and has been subjected to much attrition. The last true molar was situated lower than the first, and was also oblique. In *Ctenacodon serratus*, the two lower molars are nearly on a level. The present specimen shows that the angle of the jaw was strongly inflected, and there was likewise a ridge on the opposite outer margin. The coronoid process had its front border more nearly perpendicular than in *Ctenacodon serratus*. There is no trace of a mylohyoid groove.

The known specimens of this species are from the Upper Jurassic deposits of Wyoming.

EXPLANATION OF PLATES VI. AND VII.

PLATE VI.

FIG. 1. Left upper jaw of *Allodon laticeps*, Marsh; outer view.
„ 2. The same specimen; seen from below.
„ 3. Left upper jaw of same species; inner view.
„ 4. The same specimen; seen from below.
„ 5. Left upper jaw of same species; outer view.
„ 6. The same specimen; seen from below.
„ 7. Right premaxillary of *Allodon fortis*, Marsh; outer view.
„ 8. The same specimen; seen from below.
„ 9. The same specimen; seen from in front.
„ 10. The same specimen; inner view.
„ 11. Portion of left upper jaw of *Allodon fortis*; outer view.
„ 12. The same specimen; seen from below.
„ 13. The same specimen; inner view.
„ 14. Lower incisor of *Allodon fortis*; side view.
„ 15. The same incisor; seen from in front.

a, last incisor; *a''*, second premolar; *b*, fourth premolar; *b'*, third premolar; *c*, second true molar; *c'*, first molar; *f*, antorbital foramen; *m*, malar arch; *s*, suture with maxillary.

Figures 1–4 are four times natural size; 5 and 6, six times natural size; 7–15, three times natural size.

PLATE VII.

FIG. 1. Right lower jaw of *Ctenacodon serratus*, Marsh; outer view.
The small figure is natural size, and the larger one is magnified four diameters.

FIG. 2. Right upper jaw of *Ctenacodon potens*, Marsh; inner view.
„ 3. The same jaw; seen from below.
„ 4. Left lower jaw of *Ctenacodon serratus*; inner view.
„ 5. Incisor, probably of same species; seen from in front.
„ 6. The same incisor; seen from the side.
„ 7. Left lower jaw of *Ctenacodon potens*; outer view.
„ 8. The same jaw; inner view.
„ 9. The same jaw; front view, with its fellow restored in place.

In Figures 2 and 3, *a'*, first premolar; *b*, fourth premolar; *c*, second molar; *m*, malar arch. In the lower jaws, *a*, incisor; *b*, condyle; *c*, coronoid process; *m*, molar; *r*, root of incisor; *s*, symphyseal surface.

Figures 2, 3, 5 and 6, are four times natural size, and Figures 4, 7, 8 and 9, are three times natural size.

(*To be continued.*)

II.—Notes on *Chondrosteus acipenseroides*, Agassiz.

By Dr. R. H. Traquair, F.R.S., F.G.S.

THE now well-known Liassic Acipenseroid fish *Chondrosteus acipenseroides* was named by Agassiz in 1843, but not described by him.[1] It subsequently formed the subject of an elaborate memoir by Sir Philip Grey-Egerton, Bart.,[2] in which, besides giving a minute account of the structure of the genus, he named two additional species —*C. pachyurus* and *C. crassior*. Putting the results of Sir Philip's investigations as briefly as possible, he maintained that while "in all essential points" *Chondrosteus* resembled the recent Sturgeon, nevertheless in certain others, and notably in the structure of the opercular and hyoid regions, it constituted a transitional form towards the more ordinary Ganoids. Moreover, the skin of the body presented the same naked condition seen in the recent *Polyodon*.

Eight years afterwards Professor Young read a paper on the subject before the Geological Society of London, of which only an abstract of six lines[3] is given in the Quarterly Journal. The object of the paper was to show that *Chondrosteus* was a Holostean, not a Chondrostean, because it "possesses a well-ossified basioccipital, and the lateral walls of the cranium are composed of bones answering to the cartilage bones of ordinary Teleostei."

In 1877 I placed the family "Chondrosteidæ" (including *Chondrosteus*) in the "Acipenseroid" suborder of Ganoids, between the Spatularidæ and the Palæoniscidæ, which latter family, along with the allied Platysomidæ, I proposed to include in one great group with the Sturgeons.[4]

On the 9th March of the present year, Mr. J. W. Davis read a paper on *Chondrosteus acipenseroides* before the Geological Society of London, of which an abstract has been published. In this paper Mr. Davis interpreted the appearances presented by a single fine specimen in his own collection, and besides giving a detailed account of its anatomical structure, expressed his belief "that there is no specific difference between *C. acipenseroides*, Agassiz, and *C. crassior*, Egerton."

Mr. Davis does not seem, however, to have made use of the magnificent suite of specimens of *Chondrosteus* in the British Museum, which contains not only the types of Sir Philip Egerton's figures, but also a splendid array of additional examples, mostly also from the Egerton and Enniskillen Collections. For the privilege of examining these, and of noting several new and interesting details presented by them, I am indebted to Dr. Woodward, F.R.S., Keeper of the Geological Department, and my thanks are due also to Dr. Geikie, F.R.S., and Mr. E. T. Newton, F.G.S., for kindly permitting me to take notes of the specimens in the Museum of Practical Geology, Jermyn Street. In the present paper I propose to give an

[1] Poissons Fossiles, t. ii. pt. 2, p. 280.
[2] Phil. Trans. vol. 148 (1858), pp. 871—885.
[3] Q. J. G. S. vol. xxii. (1866), p. 596.
[4] Ganoid Fishes of the British Carboniferous Formations, Pt. I. Palæoniscidæ, p. 42, Pal. Soc. 1877.

outline of the results derived from the study of the specimens in both Museums.

Cranial Shield.—The elements of the main portion of the cranial shield have been recognized by Sir P. Egerton and by Mr. Davis, the former of whom enumerates "the parietals, the mastoids, the frontals, and the prefrontals,"—the latter stating that the "frontals, post-frontals, parietals, mastoid, and some of the occipital plates are present." This cranial shield is exhibited in many of the British Museum specimens, but in none have I seen it better displayed than in one belonging to the Museum of Practical Geology, from which Fig. 1 has been taken. Here we have two oblong *parietals* (*p.*)

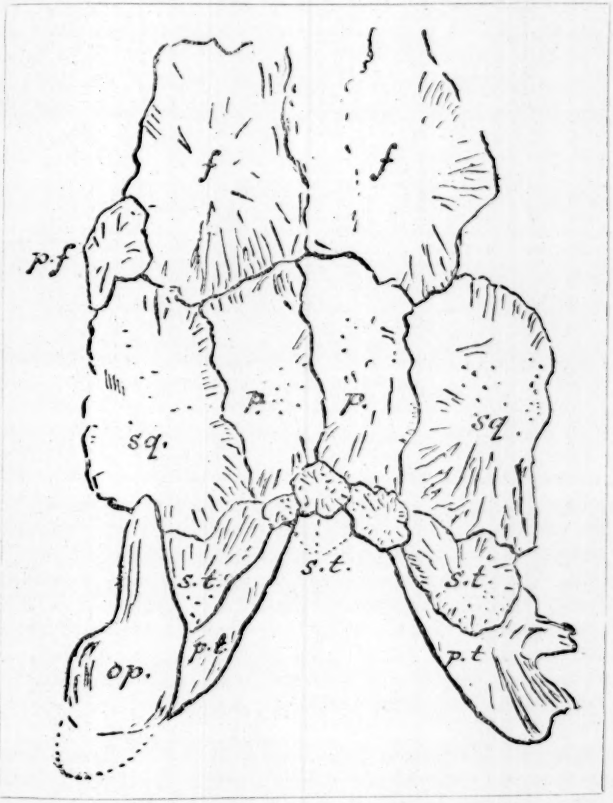


Fig. 1.—Cranial shield of a specimen of *Chondrosteus* in the Museum of Practical Geology, Jermyn Street. On the left side the displaced operculum (*op.*) is seen overlapping the post-temporal (*pt.*) and outer supra-temporal (*st.*).

joining each other in the mesial line, and each is flanked externally by a rather larger *squamosal* (*sq.*), the "mastoid" of a bygone

nomenclature. In advance of the two parietals are two large *frontals* (*f.*), also in apposition mesially, while posteriorly, and externally, each of them also touches the squamosal of its own side. Then, occupying a corner between the hinder part of the external margin of each frontal and the anterior external margin of the corresponding squamosal, is a rather small *posterior frontal* (*p.f.*). In no specimen which I have seen are the plates in advance of the frontals in sufficiently good preservation to enable one to map out or describe them: the outline of the snout as given in the restoration (Fig. 5) is therefore conjectural. Behind the posterior margins of the parietals and squamosals, and between these and the post-temporal elements of the shoulder-girdle, is a transverse row of five small plates (*s.t.*). One of these, of a rudely polygonal shape, is median, and placed just at the union of the two parietals, and is flanked on each side by another plate, of which the right is larger, the left smaller than itself. External to each of the latter is the remaining plate of each side, of considerably larger size, of an irregularly triangular shape, and placed between the posterior margin of the squamosal and the post-temporal (*p.t.*), which latter it largely overlaps. These are certainly the plates which in other Ganoid fishes (*Lepidosteus*, *Polypterus*) have sometimes been called "supra-occipitals" and "epiotics," but they are mere scale-bones, and occupy the place of the *supra-temporal* chain in Teleostei.

A very distinct *suborbital* bone (*s.o.* Fig. 5) is seen in a large number of specimens. It consists of two limbs—an upper and longer vertical one meeting below at nearly a right angle with a shorter horizontal portion, the bone being considerably expanded at the junction. Above, the suborbital was suspended from the post-frontal region of the cranial shield,—below, it comes in contact with the middle of the maxilla. This suborbital is the bone which Sir Philip Egerton has interpreted as the "præmaxilla" in his memoir.

All these plates are externally marked with pores, and often with furrows and ridges radiating from the centres of ossification; often also the surface becomes corrugated, sometimes almost granulated; but I have seen no positive traces of ganoine upon the surface.

Internal Cranial Bones. — There is a large parasphenoid much resembling that of *Acipenser* in shape; but, unlike Prof. Young, I can find no remains of ossification in the chondrocranium, which can be described, or even relied upon as being such. Although such ossifications may very likely have existed, it seems very improbable that they attained any considerable dimensions.

Hyoid Arch.—The most easily recognized bone of the entire head is the *hyomandibular* (*h. m.* Figs. 2 and 5), which passes from the squamosal region obliquely downwards and backwards. It is shaped much as it is both in *Acipenser* and *Polyodon*, being constricted in the middle and flattened anteroposteriorly in its upper part, laterally in its lower. In one specimen in the British Museum there is an appearance as of an ossified symplectic, extending from the lower extremity of the hyomandibular towards the articulation of the mandible; this I do not insist upon, as it is not corroborated by any

In this specimen the head is seen obliquely from below and affords an excellent view of the shoulder-girdle, opercular apparatus, roof of the mouth, and inner surface of a portion of the cranial shield.

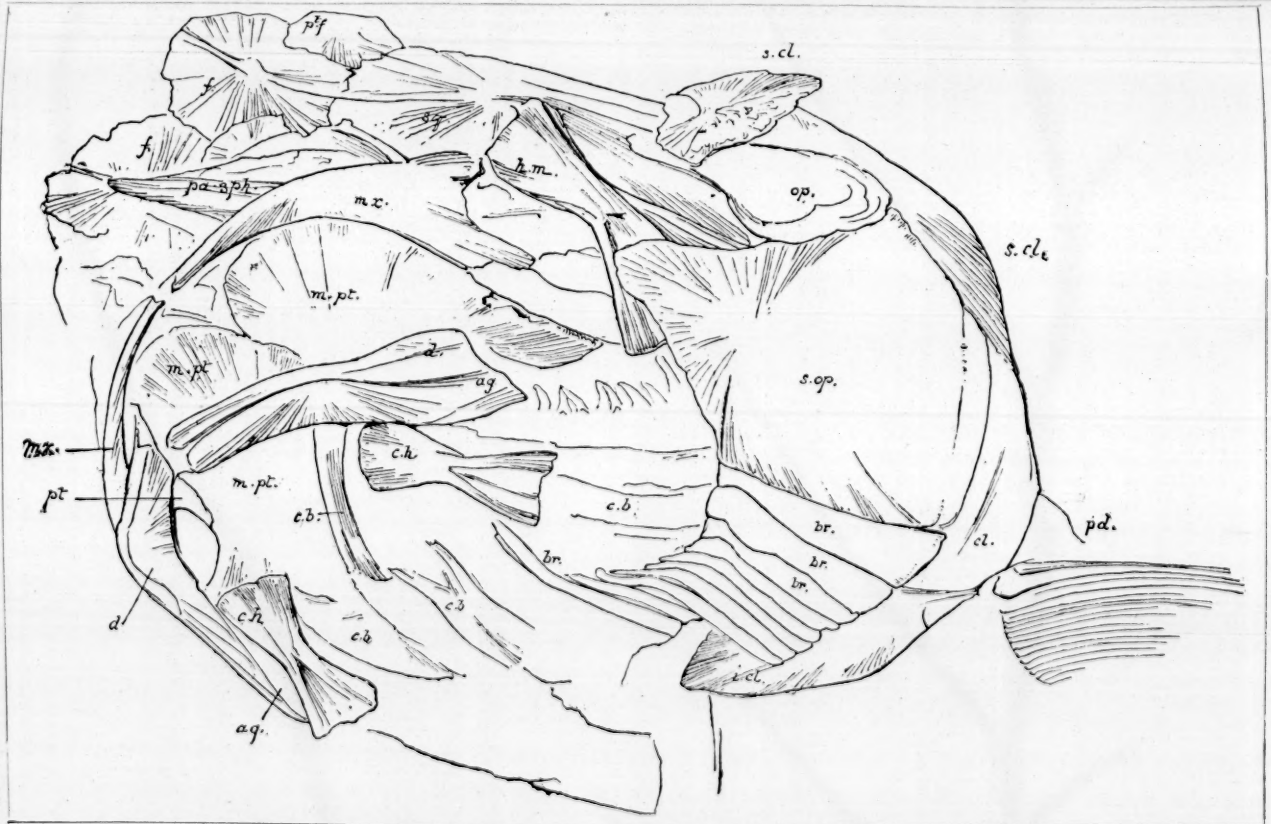


FIG. 2.—Head of *Chondrosteus* (British Museum, No. P. 2049). [Egerton Collection.] See explanatory note at foot.

other specimen. though the existence of a cartilaginous one may be safely assumed considering the large space between the lower extremity of the hyomandibular and the articulation of the lower jaw.

The *ceratohyal* (*c. h.* Figs. 2, 3, and 5) is also very easily recognizable, and requires no special description.

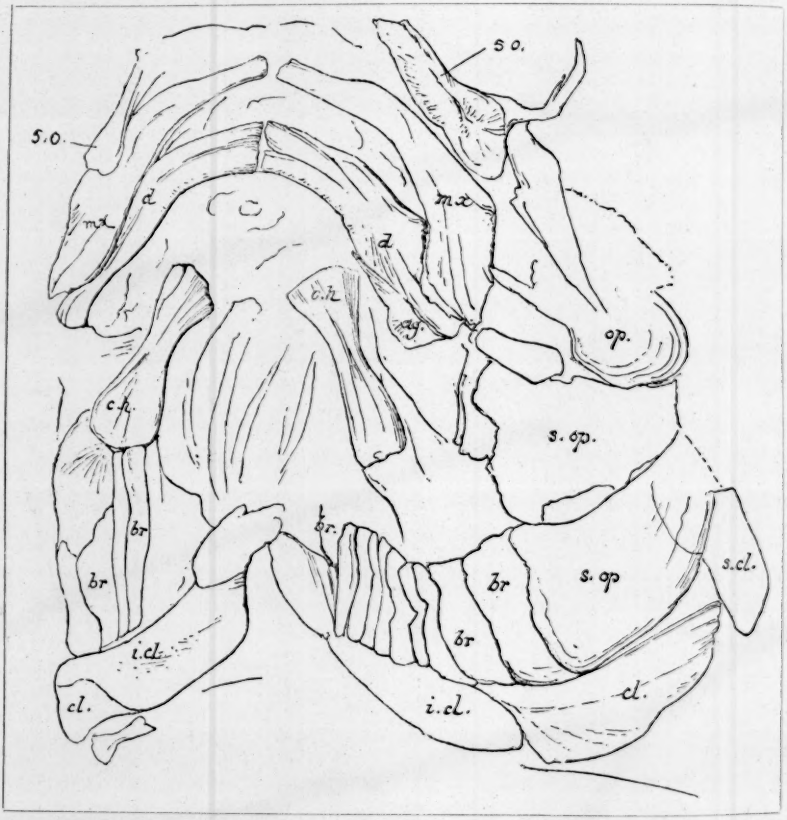


FIG. 3.—Head of *Chondrosteus* (British Museum, P. 2048), seen obliquely from below, showing the position of the mouth and the symphyses of both maxillæ and mandibles. The suboperculum and branchiostegal rays are somewhat injured.

Opercular apparatus.—The opercular flap is principally supported by a large, broad, somewhat irregularly rhombic plate (*s. op.* Figs. 2, 3, and 5), overlapping, with its anterior superior angle, the posterior inferior part of the hyomandibular, and leaving a considerable space between its upper concave margin and the edge of the cranial shield. This is the bone which has hitherto been called "operculum" in *Chondrosteus*, and it certainly corresponds exactly in position to the so-called operculum in *Polyodon*. It is, however, equally clear that it corresponds also in position, as well as in general

shape, with the suboperculum of *Palæoniscus*;[1] and that this is its true interpretation is proved by the discovery of the proper operculum (*op.*) lying above it and between it and the cranial shield (Figs. 2, 3, 5). The shape of this operculum may be aptly likened to that of an inverted comma, the tail passing upwards and forwards to the cranial shield, the convex margin being posterior and the concave one anterior, a considerable space in front of the bone and above the suboperculum being still left uncovered. The opercular flap is continued downwards and forwards by a series of ten imbricating *branchiostegals* (*br.*), which are broad and plate-like where they immediately follow the suboperculum, though anteriorly they become narrow and slender.

Jaws and palato-quadrate apparatus.—The maxilla (*mx.*) is a tolerably stout bone, tapering anteriorly and somewhat expanded in its posterior third—the posterior margin looking very obliquely upwards and backwards. As is well shown in Figures 2 and 3, it is curved inwards in front to meet its fellow of the opposite side in a perfect symphysis; there cannot, therefore, be a true præmaxilla here any more than in *Acipenser* or *Polyodon*. Articulated to the oblique posterior margin of the maxilla is a small flat plate (*j*), whose shape somewhat reminds one of a boot, the sole being in apposition with the maxilla, while the leg is directed upwards and backwards towards the anterior margin of the suboperculum (see Fig. 4, *j*). This is clearly the homologue of the little bone which in the recent Sturgeon is called "præoperculum" by Mr. W. K. Parker,[2] although it seems to me and others to be the same "jugal" element which we find appended to the maxilla in *Amia*, *Salmo*, etc. In the Sturgeon it has also been called "maxilla" by some who looked upon the real maxilla as a "præmaxilla,"[3] and this seems to have been Sir P. Egerton's view when he assigns a præmaxilla as well as a maxilla to *Chondrosteus*. But an examination of the original specimen represented in pl. lxix. of his memoir shows that his "præmaxilla" is the suborbital bone, and that his maxilla—the small bifurcate bone behind it—appertains to the palate, and will be described immediately as a pterygoid element! The real maxilla in this specimen is interpreted by Sir Philip as a mandible, while to this jugal plate he has assigned the name and position of *hypotympanic* (=quadrate).

Within the space bounded by the maxillæ, the roof of the mouth is principally composed of two plates (*m. pt.* Figs. 2 and 4) of a somewhat oval or ovoid contour, narrower behind than in front. Anteriorly, these plates are placed behind the symphysis of the maxillæ; mesially, they articulate with each other along a portion of their internal margins, while externally each comes into contact with

[1] Described as "interoperculum" in my Memoir on the Structure of the Palæoniscidæ. I have, however, abandoned that view, and now consider the plate intercalated between it and the operculum in such genera as *Rhabdolepis* to be not a suboperculum, but merely an accessory element.

[2] "On the Structure and Development of the Skull in Sturgeons," Phil. Trans. vol. 173 (1881), p. 172.

[3] See Stannius, "Handbuch der Zootomie der Wirbelthiere," erster Theil, Die Fische, p. 53.

the maxilla of its own side for the anterior half of its length, behind which the margin recedes inwards, the little bone *pt.* being placed just where the recession takes place. These plates were recognized by Sir Philip Egerton as "palatine," and are undoubtedly the representatives of the two plates occupying a corresponding position in

FIG. 4.—Palatal apparatus of left side of head of *Chondrosteus*, seen from above. Drawn from specimen in the Enniskillen Coll. No. P 3367, in the British Museum. *m. pt.* = mesopterygoid. *mx.* = maxilla. *j.* = jugal. *pt.* = pterygoid, or ectopterygoid.

Acipenser, and which, although formerly usually reckoned as "palatines," are designated as "pterygoids" by Prof. W. K. Parker.[1] To my mind it seems to correspond more with the *mesopterygoid* of other fishes, and I have lettered it accordingly.

Placed at the middle of the outer edge of this last described bone, and articulating both with it and with the maxilla, is a small

[1] *Op. cit.* p. 172.

bone (*pt.*) which bifurcates posteriorly, one limb being placed along the middle, the other along the mesopterygoid palate-plate. This is the bone which Sir Philip Egerton has interpreted as "maxilla" (*op. cit.* pl. lxix. 21), but whose true relations are most clearly seen in a large number of specimens in the British Museum. These relations are not obscure even in the specimen figured by Sir Philip; but here, as already explained, he unfortunately mistook the real maxilla for the lower jaw. As the position of this little bone is about the middle of the maxilla and *behind the suborbital*, we may feel a little surprised at the following statement in the published abstract of Mr. Davis's paper:—"From the position of the respective maxillary and premaxillary bones in this (Mr. Davis's) specimen, there can be no further doubt that the small bifurcated bone of *C. acipenseroides*, Ag., described as the maxillary bone, is really the premaxillary."

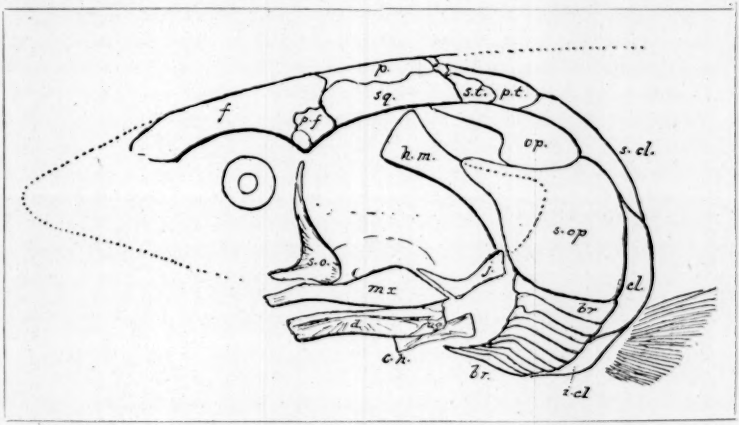


FIG. 5.—Profile of head of *Chondrosteus*, restored.

But if we inquire what this little "bifurcated bone" really is, I answer that it seems to me to occupy, as regards the maxilla and the great palate-plate, a position quite analogous to that of the small bone in *Acipenser* lettered as "palatine" by Professor W. K. Parker, but which I have come to look upon as a *pterygoid* or *ectopterygoid*, for the same reasons which have induced me to regard the great palate-plate as a mesopterygoid, and as such I have accordingly marked it.

I have seen no evidence of ossified quadrate or metapterygoid elements. There can be no doubt that the bone interpreted by Sir Philip Egerton as a combined "mesotympanic" and "hypotympanic" (*symplectic* and *quadrate* of modern nomenclature), is that external plate appended to the hinder extremity of the maxilla, which I have already described as the *jugal*.

The mandible is stout, and anteriorly is, like the maxilla, strongly curved inwards to meet its fellow of the opposite side in a symphysis: its outer surface presents a well-marked longitudinal groove, which

approaches close to the superior margin about the middle of its extent, and then diverges downwards and backwards towards the angle. Sir Philip Egerton describes the mandible of each side as a single bone, and no doubt it is mostly composed of a large dentary element (*d.* Fig. 3). But at its posterior extremity two other elements are undoubtedly present, of which one, the upper, may be reckoned as *articular*, while the other beneath it is unquestionably the *angular* (*ag.*).

No trace of teeth can be seen in connection with either jaw; *Chondrosteus* in this respect, as in so many others, resembling the recent *Acipenser*.

Branchial skeleton.—Abundant remains of ossified *cerato-branchials* (Fig. 2. *c. b.*) are seen in many of the specimens, but we need not be detained at present by entering into detail as to this part of the skeleton.

Shoulder-girdle. — Sir Philip Egerton states that whereas in *Acipenser* three bones are present in the shoulder-girdle, viz. supra-scapular (post-temporal), scapular (supra-clavicular), and coracoid (clavicle), in *Chondrosteus* the "scapula" and "coracoid" have coalesced. In *Acipenser* there are, however, at least four membrane bones of the shoulder-girdle; the post-temporal being however immoveably articulated with the cranial shield, while the fourth element is the large infra-clavicular plate. And Mr. Davis, as regards *Chondrosteus*, is undoubtedly right in maintaining that the "scapula" and "coracoid" are not fused, though, as he enumerated only three elements in the shoulder-girdle, he seems not to have observed the infra-clavicular.

The *post-temporal* (Figs. 1 and 2, *p. t.*) is a somewhat three-cornered plate placed behind the posterior margin of the cranial shield, and having its anterior margin overlapped by the supra-temporal bones. This is followed by the *supra-clavicular* (Fig. 2. *s. cl.*), an oblong bone passing obliquely downwards and backwards, and having its upper extremity obliquely perforated by the side-canal. Its distinctness from the clavicle is obvious in every well-preserved specimen. This clavicle (Figs. 2 and 3, *cl.*) differs from that of the Sturgeon in not being so much developed inferiorly, so that the next element, the *infra-clavicular* (*i. cl.*) articulates to its lower margin, extends higher up, and comes to be opposite a considerable portion of the origin of the pectoral fin. There is still another plate (Fig. 3, *p. cl.*), though it is a very small one, appended to the posterior margin of the clavicle, and this we may recognize as corresponding to the *post-clavicular* of *Polyodon* and the Palæoniscidæ.

I have seen no evidence of ossification in the scapulo-coracoid cartilage, nor does any specimen afford a view of the base of the pectoral fin, though in some a few dislocated radials may be seen in this position. It is probable that the arrangements here resembled those in *Acipenser*, and I own I am somewhat at a loss to understand the "two bones" to which Mr. Davis alludes as "apparently representing the radius and ulna of Owen (coracoid and scapula of Parker)."

The limits of the present paper hardly permit my entering into detail as to the rest of the structure of *Chondrosteus*. So far as the internal skeleton is concerned, its remains indicate a structure very similar to that in *Acipenser*, while the fins in shape and arrangement much resemble those of *Polyodon*.

Conclusion.—Although there is no evidence of any long snout, *Chondrosteus* resembled *Polyodon* in the general shape of the body, in the form and arrangement of the fins, and, above all, in the absence of *scales* on any part, save the prolongation of the body-axis along the upper lobe of the very heterocercal tail. In other respects its affinities are more with *Acipenser*.

How like the corresponding parts in *Acipenser* are the suborbital bone, the edentulous jaws, the jugal bone, and indeed the palatal apparatus, though that has also its own peculiarities; while it seems highly probable that the mouth was protrusible as in the living Sturgeon.

But where the resemblances to *Acipenser* become weaker, they come to point in another direction, namely, that of *Palæoniscus*, and of course through the Palæoniscidæ to the truly "teleosteoid" Ganoids. This is in the first place well seen in the cranial shield (Fig. 1) where the parietals and frontals are mesially in contact with each other for their whole length, where there is a well-marked supra-temporal chain, and where the post-temporal is moveably articulated, —whereas in *Acipenser* the frontals are entirely separated by an intercalated plate, and the post-temporals and two of the median body-plates are immoveably joined to, and form a part of the cranial buckler itself. Especially palæoniscoid is, however, the aspect of the opercular and branchiostegal apparatus, as will be seen if the reader will compare the restored drawing (Fig. 5) with the figures of the heads of *Palæoniscus* and *Nematoptychius* given in my account of the Palæoniscidæ, although in *Chondrosteus* there is no præoperculum and the series of branchiostegal rays of the two sides may not have met in the middle. The special resemblance of the shoulder-girdle to that of *Palæoniscus* is also very striking, especially in the form of the post-temporal and supra-clavicular bones.

In my already-quoted essay on the structure of the Palæoniscidæ, I pointed out certain strange and previously unrecognized resemblances which *Palæoniscus* bore to *Polyodon*, especially in the internal skeleton, the shoulder-girdle, and the jaws and palato-quadrate apparatus (even although there *are* premaxillary bones and there is no evidence that the palato-quadrate elements met in the middle line in front). I also remarked that the resemblances between *Palæoniscus* and *Acipenser* are of course much less prominent. Here, however, is a form which in many of its features presents strong Palæoniscoid resemblances, but whose affinities are, nevertheless, more with *Acipenser* than with *Polyodon*!

The affinities of *Chondrosteus* seem, therefore, to radiate in three directions, towards *Acipenser*, towards *Polyodon*, and towards the Palæoniscidæ, and certainly, of all the three directions, the distance towards *Acipenser* is the least.

III.—British Liassic Gasteropoda.

By E. Wilson, F.G.S.; Curator of the Bristol Museum.

(*Concluded from* p. 202.)

Cerithium trigemmatum, spec. nov. Pl. V. Figs. 10, 10*a*.

Description.—Shell conical, turrited; apex acute; spiral angle regular, whorls 8–9, angularly carinated anteriorly; sutures wide and deep; each whorl bears 3 spiral rows of equally spaced but unequal neatly rounded tubercles; the anterior of these, which are much the largest, are set on the carina; the middle row consists of fine granules, whilst the nodules of the posterior row, which adjoin the posterior suture, are intermediate in size and half-way between the other two. Fine, close-set curved striæ of growth cross the whorls transversely, but are scarcely discernible even with a lens, except on the last whorl of well-preserved specimens. Last whorl bicarinated by a fourth very finely granular raised line, between which and the coarsely nodulated carina is a plain encircling thread; base flattish, bearing a few concentric raised lines. The aperture is imperfect in all the specimens I have examined, but is roundly ovate in form, and occasionally shows slight indications of the commencement of an anterior canal. I therefore assign this species to the genus *Cerithium*.

Dimensions.—Length, 7·5 millimètres; diameter, 2·5 mm.; spiral angle, 22°; sutural angle, 97°.

Geological Position and Locality. — Lower Lias, zone of *Am. oxynotus*, Railway-tunnel, Old Dalby, Leicestershire.

Actæonina ferrea, spec. nov. Pl. V. Figs. 11, 11*a*.

Description.—Shell pyriform, smooth and shining; spire depressed near the shoulder of the last whorl, but presenting a small pyramidal elevation in the centre; this portion of the shell is badly preserved, but the total number of the whorls appears to be 5; a narrow groove encircles the shoulder of the last whorl above (posterior to) the rectangulated keel. The aperture is almost entirely concealed in my sole specimen, but it widens out somewhat towards the anterior extremity, and the inner lip is thin with a sharp edge anteriorly, without any fold or thickening over the columellar region. A few (5 or 6) fine encircling striæ are discernible on the anterior portion of the last whorl.

Dimensions.—Length, 7·5 mm.; diameter, 5 mm.; length of last whorl, 6·75 mm.

Geological Position and Locality.—Middle Lias, Marlstone Rock, zone of *Am. spinatus*, East Norton Embankment, derived from Tilton, Leicestershire.

Cylindrites æqualis, spec. nov. Pl. V. Figs. 12, 12*a*.

Description.—Shell ovately and regularly fusiform; spire moderately elevated, obtusely conical; apex acute; whorls 5, slightly convex, embracing, with narrow ill-defined sutures. A narrow impressed line

encircles the whorl a little in front of the suture, between which there is a narrow raised encircling band; the aperture is, unfortunately, not well shown; it occupies five-sixths of the length of the last whorl, the anterior extremity is acutely angulated, with thickened margins, and there is a distinct spiral fold on the columellar border anteriorly. The shelly matter has disappeared, but the surface appears to have been originally smooth.

Dimensions.—Length, 11·5 millimètres; diameter, 5·75 mm.; length of last whorl, 10 mm.

Geological Position and Locality.—Middle Lias, Marlstone Rock, zone of *Am. spinatus*, East Norton Embankment, derived from Tilton, Leicestershire.

British Liassic Alariæ.

It has often been supposed that the section of winged shells *Aporrhaidæ*, and genus termed *Alaria* by Lycett, but more clearly defined by Piette, did not appear in the British area until the commencement of the Oolitic period. This is certainly a mistake. Although extremely rare in the Lias, there are undoubted instances of the occurrence of *Alariæ* even in the Lower division of that formation. Messrs. Tate and Blake do not record this genus from the Yorkshire Lias. In his valuable "Contributions to the Palæontology of the Yorkshire Oolites," Mr. W. H. Hudleston, F.R.S., referring specially to the Yorkshire area, observes that "It was in the Lower Oolite that the genus *Alaria* first began to flourish, and we find that it became tolerably well represented as low down as the Inferior Oolite or Bajocian subdivision" (Geol. Mag. Dec. III. Vol. I. p. 145, 1884). In the year 1867 the late Charles Moore described three species of *Alaria* from the Upper Lias of Somersetshire, viz. *A. unispinosa*, Moore; *A. coronata*, Moore, and *A. angulata*, Moore. The first of these certainly, and the last two probably, are true *Alariæ*. Since then other examples of this genus have been found in different portions of the English Lias. Mr. T. Beesley, F.C.S., whose valuable labours in the Lias of Oxfordshire are widely known, informs me that he has obtained the moulds of two *Alariæ*, which he takes to be *A. coronata* and *A. angulata*, from the Upper Lias shales (lower portion of zone of *Am. communis?*) of Bloxham, Oxon. Mr. E. A. Walford, F.G.S., of Banbury, records an *Alaria* (*A. unispinosa*, query *A. semicostulata*) from the Upper Lias of Chipping Warden, Northamptonshire. Mr. B. Thompson, F.G.S., has shown me imperfect specimens of an *Alaria*, which may be *A. unispinosa*, from the Upper Lias (zone of *Am. serpentinus*) of Alderton, Gloucestershire, and Mr. W. D. Crick has recently forwarded me specimens from the Upper Lias of Chipping Warden, and of Burrow Hill, Dodford, Northamptonshire, which are very closely allied, if not, indeed, identical with *A. semicostulata*, Piet. et Eug. Desl. Last year I had myself the good fortune to find a single well-marked example of this genus in the Lower Lias of Bitton, near Bristol, Gloucestershire.

In his classical paper on "Abnormal Secondary Deposits in the

West of England," the late Charles Moore described two incomplete shells from the Lower Lias coralliferous conglomerate of Brocastle, Glamorgan, under the names *Alaria rudis*, Moore, and *A. fusiformis*, Moore (Q.J.G.S. vol. xxiii. p. 566, pl. xiv. figs. 24, 25). Having lately examined these specimens in the Bath Museum, I would question very seriously the generic appellation given to these fossils. In their general proportions both these shells are very unlike typical *Alariæ*, and seeing that they show no distinct canal or trace of digitation, their identification as such must be considered doubtful. On the other hand, there are a few forms in the "Moore Collection" at Bath, at present ascribed to other genera, which may eventually be shown to belong to the genus *Alaria*. For the present, the little shell from the Lower Lias of Bitton, Gloucestershire, must, I believe, be considered the earliest definitely established British *Alaria*, if not indeed the earliest known example of that genus.

ALARIA HUDLESTONI, spec. nov. Pl. V. Fig. 13.

Description.—Shell turrited, scalariform; apex acute; spiral angle slightly concave; whorls 8–9, quadrangular and rectangularly bicarinated, with wide and deep sutures; the carinæ each bear a finely-granulated thread over the angle, the posterior of which is rather more prominent, and causes this keel to project a little more than the anterior one; the posterior carina is encircled anteriorly by a narrow impressed line; the whole of the spire and apparently also the base is covered with fine oblique radial lines; in the earlier whorls the anterior carina is submedian and much more prominent, and is coronated over the angle by vertical costæ, whilst the posterior carina is much less prominent; the base of the shell is almost flat, it bears 3 or 4 widely-separated concentric raised lines. The wing consists of a single digitation, which has a general direction at right angles to the axis of the shell; this is wide at its origin, directly below the anterior carina of the last whorl, after proceeding a short distance it suddenly narrows, and then soon tapers away to its rather blunt and slightly recurved extremity. Canal unknown, the canal-sheath being broken off at its origin.

Dimensions.—Length of shell without the canal, 7·5 millimètres; diameter of last whorl, 4 mm.; breadth of same, with wing, 8 mm.; spiral angle, 30°; sutural angle, 105°.

Obs.—I name this interesting fossil after Mr. W. H. Hudleston, M.A., F.R.S., who has contributed so largely to our knowledge of the Gasteropoda of the British Oolites.

Geological Position and Locality.—Lower Lias, zone of *Am. Bucklandi* (lower portion), Stout's Hill, Bitton, near Bristol, Gloucestershire.

ALARIA SEMICOSTULATA? Piet. et Eug. Desl. Pl. V. Figs. 14 & 15.

1864. *Alaria semicostulata*, Piet. et Eug. Desl. Pal. Fr. Terr. Jur. Gast. vol. iii. p. 18, plate i. figs. 7—9.

The following description of the more perfect of Mr. Crick's specimens will be found to agree pretty closely with that given by Piette (*l.c.*).

Description. — Shell turrited, fusiform; spiral angle regular; whorls 9 or thereabouts, convex, very feebly carinated a little anterior to the middle line, and ornamented by several fine spiral threads of unequal thickness. In one specimen (Fig. 14), which is the more complete of the two, but is imbedded in the rock so as not to show the aperture, there are on the penultimate whorl 11–12 threads. Of these four are coarser than the rest; two of those which are most prominent and subcentral in position determine the faint keel; the other two are anterior to these; between the second and third, and also between the third and fourth, of these coarser threads, counting from the anterior suture, there is a fine line; posteriorly to the fourth coarse thread there are two threads of medium coarseness with a fine thread between them, and there are two or three more fine threads between the last of these and the posterior suture. Crossing these are numerous inconspicuous curved radial lines of growth. The earlier whorls are badly preserved, but enough remains to show that they bear strong straight radial costæ; these costæ disappear on the later whorls, and there are no signs of them on the last two or three. The canal-sheath, uniformly slender from its origin, is prolonged in a straight line axially to its termination; it is striated by fine oblique lines. (In Piette's type the canal was broken off short, so that the character of its termination could not be given.) The aperture and ultimate wing (l'aile définitive) are not shown, but the character of the latter is indicated by a single longish slender spine, which originates from the posterior line of the keel, making an angle of 68° with the axis of the spire.

Dimensions.—Height, including the canal, 19 mm.; height, without the canal, 14 mm.; greatest breadth of last whorl, exclusive of the wing, 8 mm.; spiral angle, 25°; sutural angle, 115°.

Geological Position and Locality.—Upper Lias, zone of *Am. serpentinus*, Burrow Hill, between Dodford and Norton, Northamptonshire.

The other specimen (Fig. 15) is much less perfect, but it agrees pretty closely with the foregoing in its general form and ornamentation. The whorls, however, appear to be more convex, with deeper sutures, and are even less perceptibly carinated; they are crossed by widely spaced slender curved radial costæ, which taper away towards the sutures, and almost disappear on the later whorls; a short spinous process remains at the opposite side to the aperture, from which point a single angular and moderately prominent keel is continued forwards: the base as well as the apex of the shell having suffered considerably, we cannot say for certain whether any more spinous processes were developed on the keel or what were the characters of the canal and the wing.

Dimensions.—Spiral angle, 25°; sutural angle, 120°.

Geological Position and Locality.—Upper Lias (transition-bed to Middle Lias), Chipping Warden, Northamptonshire.

Obs.—There are minor differences in form, and in the number and arrangement of the spiral lines, between the above shells and between each of them and Piette's figure of *Alaria semicostulata*. The shell from Burrow Hill (Fig. 14) evidently does not

exhibit its full growth, so that it is impossible to say whether an angular carina sets in on the last whorl or not. Judging by its general agreement with our other specimen, I am inclined to think it would, and in that case the chief difference between this shell and *Alaria semicostulata* disappears. Again, in the Chipping Warden specimen (Fig. 15) the whorls are more rotund and more deeply sutured than in the enlarged figure of *A. semicostulata*, given by Piette, or in the first above-described specimen. Slight variations in the convexity of the whorls, in the depth of the sutures, spiral angle, and arrangement of the spiral lines, are not by themselves characters of specific value amongst otherwise similar *Alariæ*; so that in face of the general agreement of these shells with *A. semicostulata*, and failing definite proof of any important distinction in the keel, the carinal spines, or the canal, I consider it safest to relegate both of the above specimens to that type.

[For the Plate and the Explanation thereof, see the May Number, p. 202.]

IV.—The Glacial Deposits of Sudbury, Suffolk.

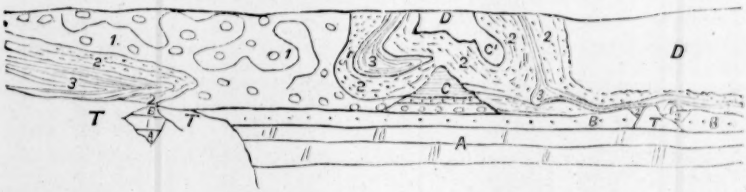
By J. E. Marr, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

THE accumulations of drift in the vicinity of the town of Sudbury have been described by Mr. Whitaker in the Geological Survey Memoir upon the N.W. part of Essex and N.E. part of Herts, etc.; and additional notes are given by the same author in the Memoir upon the Geology of Ipswich, etc. Since the appearance of these memoirs the sections have altered considerably, and one of the exposures is of such interest, that a record of it seems to me desirable, as in a few years it will be doubtless destroyed, and one more link in the chain of facts which have to be considered in attempting to account for the mode of formation of these drifts will have disappeared.

I wish to express my indebtedness to Dr. J. S. Holden, F.G.S., who has kindly accompanied me to the principal exposures, and furnished me with much information.

Fig. 1.—Section in Mr. Green's Pit N.E. of Sudbury.

S. Length of Section about 100 feet. N.

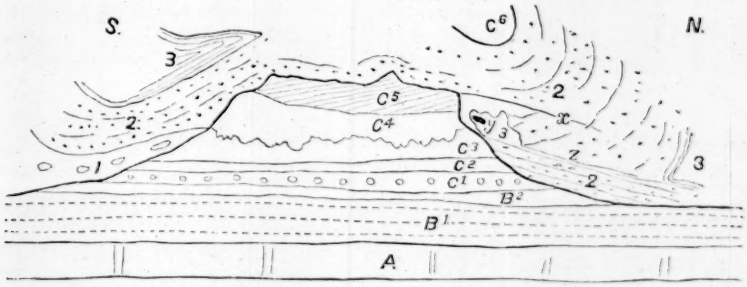


A. Chalk.
B. Thanet Sands.
C. Red Crag.
C'. Red Crag caught up in drift.
1. Boulder-clay.
2. Gravel and sand.
3. Loam.
D. Gravel dug over and filled in.
T. Talus.

The section to which I would call special attention is seen in Mr. Green's pit, about a quarter of a mile N.E. of Sudbury Town Hall. The accompanying Figure (Fig. 1) shows its appearance at the

present time (March, 1887). The Chalk, which is worked to a depth of many feet, is succeeded by the clayey green sand with green-coated flints, referred by Mr. Whitaker to the Thanet Sands. The bed is partly removed at one point, near the north end of the section, but elsewhere it has its full thickness, which is ascertained where the green sand is succeeded by an upper deposit resting conformably upon it; this is the red clay, B^2 of Fig. 2, which only occurs in one part of the pit underneath a remarkable ridge of Red Crag to be now described. The ridge is marked C in Fig. 1, and an enlarged sketch of it is given in Fig. 2. The lower part consists of the

Fig. 2.—Enlargement of the Crag Ridge in Fig. 1 (Mr. Green's Pit).



A^1. Chalk.
B^1. Green clayey sand } Thanet Sand.
B^2. Red clay }
C^1. Pebble bed.
C^2. Hard dark brown very ferruginous gravel } Red Crag
C^3. Bleached (yellow-green) sand }
C^4. Rust-red sand, not laminated }
C^5. Rust-red sand, very finely laminated }
C^6. Bleached (yellow-green) sand in the drift }

1. Boulder-clay.
2. Sand and gravel.
3. Loam.
x. Iron staining from Crag Ridge.
y. Fragment of Bed C^2 included in drift.
z. Marked divisional plane (fault ?).

pebble-bed with phosphatic nodules described by Mr. Whitaker (Q.J.G.S. vol. xxx. p. 401). This is marked C^1 in Fig. 2. Next above it is a coarse sandstone C^2 with a few pebbles, the whole being hardened by a ferruginous cement which gives the rock a very dark-brown colour. The united thickness of these beds is about 2 feet 6 inches. The main part of the ridge is formed of about 8 feet of fine incoherent quartz-sand, stained rusty red at the summit, but bleached to a pale yellow-green hue at the base. The bleached part C^3 and the lower portion of the unbleached part C^4 are devoid of lamination planes, though some planes of deposition are visible; but the top of the ridge C^5 is formed of a finely-laminated sand, the laminæ being quite regularly inclined at a very low angle towards the south. It will be seen that not only are the bedding planes between the Chalk and the Thanet Sands, and between the latter and the Red Crag, quite regular, but that the divisional planes of stratification and lamination in the latter, which stands up as a ridge in the middle of the drift accumulations, are absolutely undisturbed.

Very different is the condition of the overlying drifts. Before proceeding to describe them, I may refer to the section fig. 17 of the Geological Survey Memoir on the Geology of N.W. Essex, etc. This section is described by Mr. Whitaker as occurring on the footpath to Chilton; it would therefore lie somewhere to the east of the section now under consideration. The structure of the Crag ridge and the disposition of the overlying drifts would seem to indicate that there was a continuation of the ridge now visible in Mr. Green's pit, in which case the ridge probably has a general E.—W. direction, as may indeed be gathered from an examination of Mr. Green's pit itself. The section figured by Mr. Whitaker is now destroyed.

The ridge in Mr. Green's pit increases in height and breadth towards the west, as shown by comparing a photograph which I caused to be taken at the end of the year 1885 with the present exposure, several feet of the face of the cliff having been cut away in the interval.

The description of the drift deposits of this pit is not quite so easy as that of the older formations. Mr. Whitaker describes the Boulder-clay in the pit on the footpath to Chilton as filling up a hollow in the gravel, but the section as drawn by him is explicable also upon the supposition that the gravel fills up a hollow in the Boulder-clay. In the case of Mr. Green's pit, I came to the conclusion that the latter was the case, and have therefore taken the Boulder-clay as the deposit which would under ordinary circumstances be the lowest. This may be the case here, even if the Boulder-clay in the pit on the footpath to Chilton is above the gravel, as Mr. Whitaker shows that there are two Boulder-clays in the area. The succession, as gathered from a careful examination of Mr. Green's pit, appears to be as follows:—

1. Boulder-clay.
2. Coarse sand and gravel.
3. Fine loam.

And this is the order in which I shall describe the accumulations.

The Boulder-clay 1—Figs. 1 and 2—consists of a very stiff brown or leaden-blue clay, having at the south end of the pit a series of wavy divisional planes. Besides this, it in places contains very close-set divisional planes, reminding one strongly of the "fluxion-structure" of igneous rocks. Along some of these carbonate of lime has collected, giving the deposit here and there a marked banded appearance. The deposit is full of boulders, mostly small, the greater number being of white chalk (often striated) and flint, but blocks of sandstone also occur, especially a port-wine red sandstone. In the north part of the pit a small patch of Boulder-clay occurs in a depression of the Thanet Sands, but separated from them by gravel. This clay forms a horizontal tongue a yard or two long, and 2 ft. 6 in. high. At the bottom of the clay, and resting on the gravel, are patches of red clay, clayey green sand, and a mixture of the two, evidently torn off from the rocks close by. The Boulder-clay probably owes its position here to a fault which appears to run

almost horizontally from the upper portion of the Crag ridge, and which brings the deposits below against beds above inclined at quite different angles. The whole arrangement of the drifts at this part of the pit is extremely difficult to comprehend.

The gravel and sand 2—Figs. 1 and 2—are stratified and frequently false-bedded. They contain a considerable intermixture of argillaceous material. The boulders are similar to those in the Boulder-clay, mainly chalk and flint. I noticed two small fragments of red chalk. The carbonate of lime has collected along divisional planes, as in the case of the Boulder-clay and of the loam. In the central part of the section the gravel undoubtedly does at present overlie the Boulder-clay, and though it is underneath it at the south end, this seems to be due to the thrusting of a trough of gravel and loam under the Boulder-clay.

The gravel is arranged around the Crag ridge in two loops, and in the northerly one a mass of sand (Fig. 1, C^1) is involved; this sand is almost certainly a piece torn off from the Crag. It is entirely different from the gravels and loams, and resembles precisely the bleached portion of the Crag ridge, being, like it, a pale yellow-green quartzose sand, devoid of lamination; moreover, here and there a few brown patches show parts that have escaped the bleaching, as is also the case with the Crag of the ridge.

The drift-gravel is in one place coloured red, viz. along a line (Fig. 2) proceeding from the northern edge of the Crag ridge. This is possibly due to subsequent infiltration, but it is also possible that small particles of the Crag have been carried down along this line. The latter certainly seemed to me to be the case on examining the coloured seam closely.

Immediately below this stained line occurred a fragment of the bed C^2 (y. Fig. 2) caught up in a small patch of loam in the centre of the gravel.

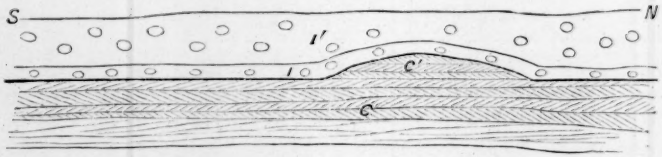
The loam 3—Figs. 1 and 2—is a stiff yellowish-brown clay, sometimes sandy, and containing comparatively few boulders. It is very finely laminated throughout. It occurs in the loop just south of the Crag ridge, and in the centre of the loop now underlying the Boulder-clay in the southern portion of the pit-face. It again occurs in a very narrow loop to the north of the Crag ridge; this expands above the plane, which is, as I have suggested, possibly a fault plane, and is then continued along this plane as a very narrow seam, sometimes only a couple of inches in thickness, above the patch of Boulder-clay before referred to, and beyond it for some yards to the extreme north end of the section.

In a pit to the east of Mr. Green's, a considerable mass of the ferruginous sands of the Crag is seen, succeeded by coarse gravels, above which comes contorted loam, in some cases bent into long horizontal loops, but no Boulder-clay is now visible. Here again the Crag sands are absolutely undisturbed, notwithstanding the violent contortion of the drifts immediately above.

Two important sections occur near the town upon the right bank of the Stour. One of these is near the summit of Balingdon Hill

(Fig. 3). The pit here is mainly cut in the ferruginous sands of the Crag, which show a total thickness of 30 feet here, without any signs of approaching the base. The beds are quite like those of the Crag ridge in Mr. Green's pit, save that they are here markedly false-bedded. The surface is perfectly even except in one place, where a rounded ridge rises up five feet above the surface of the surrounding sand (C', Fig. 3). The Crag is succeeded here by Boulder-clay, which is at the top an ordinary blue laminated Boulder-clay, with the usual scratched chalk boulders, as well as others of flint, oolitic limestones, sandstones, etc., and below this two feet of a sandy laminated Boulder-clay, of a reddish colour, the sand being evidently derived from the underlying Crag.

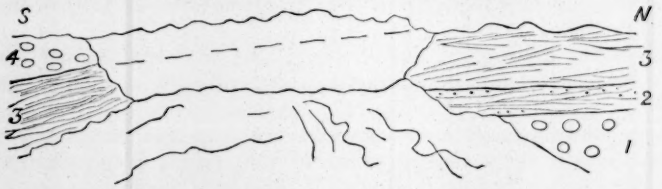
Fig. 3.—Pit on Balingdon Hill.



C. False-bedded sands, ferruginous above, bleached at base, 25 feet seen } Red
C'. Ditto bleached, projecting into drift, 5 ft. } Crag.
1. Sandy laminated Boulder-clay, 2 ft.
1'. Blue laminated Boulder-clay, to 10 ft.

The last section I shall notice is in Mr. Allen's pit, close to the river-side, and about half a mile south-east of the last-mentioned exposure. This appears to be the pit described by Mr. Whitaker as the 'Grove.' It is of interest as showing two Boulder-clays (cf.

Fig. 4.—S. end of Mr. Allen's Pit, Sudbury.



1. Lower Boulder-clay, 20 ft. seen.
2. Sand and gravel, 10-12 ft.
3. Loam, to 15 ft.
4. Upper Boulder-clay, to 16 ft.

Fig. 4). The lower one is a leaden-blue clay, often very dark, laminated, and with many chalk boulders, twenty feet being seen, and Mr. Allen informed me that below it a hard sandy rock occurred with a band of round pebbles below, almost immediately underlain by the Chalk. The hard sandy rock and pebble bed are most probably the beds of the Crag which are seen at the bottom of the ridge in Mr. Green's pit. It will be noticed that the base of the drift is here about 150 feet below its position on Balingdon Hill.

The Lower Boulder-clay is succeeded by sand and gravel, altogether like that of Mr. Green's pit, so that description is unnecessary. The same may be said of the succeeding loam, which is here rather more sandy than on the left bank of the Stour.

The Upper Boulder-clay is lighter than the Lower, but otherwise altogether like it; but it contains thin seams of gravel and loam. A large number of boulders were lying in the pit, probably from both clay and gravel, and consisting of various schists, granites, fragments of basaltic columns, limestones, sandstones, etc.

The sands, gravels, and loams in this pit are, as in the case of those on the left bank of the Stour, very extensively contorted.

So much for the facts. It remains to be considered what light, if any, they throw upon the origin of these particular drifts. That we do want some light is evident, when we find some writers assigning a marine origin to the East Anglian drifts, others a terrestrial one, whilst Mr. Searles Wood, jun., in his last communication concerning these drifts (Q.J.G.S. vol. xxxvi. p. 457), calls into play the agency of both land-ice and the sea. I wish it to be understood that the following remarks apply only to the actual Sudbury sections.

The great difficulty connected with the above-described sections is the occurrence of intensely-contorted drifts upon an irregular surface of absolutely undisturbed Tertiary beds, which are now, with one exception (the top of the Crag pebble bed), in a soft and incoherent state. Two questions suggest themselves:

1. Were the contortions produced in the area in which the contorted beds now lie, or were the contorted deposits borne from a distance?

2. If the former, why are not the incoherent beds, on which these contorted deposits rest, themselves disturbed?

In answer to the first question, it may be confidently stated that the contortions were produced in the beds in the area in which they now lie, firstly, because the contortions adapt themselves to the irregularities of the surface on which the contorted beds rest, as seen in the case of the Crag ridge in Mr. Green's pit, and of a section figured by Mr. Whitaker as occurring on the east side of a chalk-pit about half a mile east of St. Peter's Church (Geol. of N.W. Essex, etc.), where the drifts are looped into a hollow in the Chalk; secondly, because the contorted deposits have been largely derived from the local rocks. Thus we find many fragments of Crag, large and small, in the gravel north of the Crag ridge in Mr. Green's pit, and fragments of the green Thanet Sand scarcely even re-made in the patch of Boulder-clay in the northern part of that pit just where the green Thanet Sand has been scooped out. Similarly, at the top of Balingdon Hill, the base of the Boulder-clay contains much Crag material. Again, Mr. Whitaker describes the passage of re-made green Thanet Sand into the actual deposit, so that the line of junction is not to be ascertained. Mr. Penning, in the same Memoir, p. 59, remarks that "the main substance of the [Boulder-]clay indeed consists of material received from rocks at no great distance from the point where it may be observed," and Mr. Dalton adds that "some parts of the Boulder-clay consist almost entirely of chalk. Where it lies directly upon the London Clay, it is often mainly composed of the latter, being a blackish or reddish-brown clay with a few pieces of chalk or other rocks." It is clear then that the

contortion was actually produced in the Sudbury area, and consequently we are led to ask the second question, why are not the incoherent beds below also disturbed?

Four suggestions have been made to account for the contortion of drift deposits:

(i.) The pressure of material from an adjoining elevation, either rock or ice.

(ii.) The removal of soluble material, as chalk or ice, from the drift.

(iii.) The grounding of true or false icebergs.

(iv.) The pressure of superincumbent land-ice.

The first explanation is inapplicable here. Not only do contortions occur in the drifts which occupy the valley bottoms, but they are also found in the accumulations which lie on the summits of ridges, as at Mr. Green's pit, and the pits near the Cemetery. As the summits of these ridges are covered with these drifts, it is clear that no higher land occurred here in Glacial times.

The second cause seems inadequate to produce the intense contortion observed in many of the pits. The amount of chalk removed cannot be very great, for the drifts are still very calcareous. A great quantity of interstratified ice may have disappeared, but would this produce such violent folds as that seen at the southern end of Mr. Green's pit? Overfolds of this nature are produced by lateral pressure, but it is difficult to see how the removal of interstratified material could cause the folding of one deposit nearly horizontally over another for distances of several yards.

In both of these cases, we have no explanation of the undoubted fact that the drifts are largely derived from the underlying rocks. The third explanation requires fuller consideration. Local rocks might undoubtedly become churned up and included in the drifts by the grounding of icebergs, and no doubt contortion can be caused thereby, though we should also expect partial obliteration of the lamination planes. Several difficulties confront us if we adopt this explanation. Firstly, the derivation of a great part of the material from local sources. If this material was denuded by icebergs, whence comes its lamination? If, on the other hand, the deposits are ordinary marine accumulations, how are we to account for the absence of fossils? The loam, which is admirably adapted for the preservation of organisms, contains patches of lignitic material, which are apparently boulders derived from some earlier forest bed, but no marine organisms. Of course, the sea might be too cold for the existence of Molluscs, but the bones of Seals ought to occur. The Greenlanders thaw out the seals which have been frozen in winter whilst diving below the ice, and other seals are taken in nets below the ice (K. J. V. Steenstrup, "Meddelelser om Grönland," part iv. p. 99). The great difficulty in the way of accepting the view that the drifts of this area were contorted by icebergs is the fact that *the incoherent Tertiary rocks immediately underneath the violently folded Glacial deposits are never contorted even when standing up in ridges* (such as that in Mr. Green's pit), *around which the drifts have been folded.* It seems absolutely impossible that they should

escape such contortion, unless they were themselves consolidated, and their nature is such that they can have been consolidated only by being frozen, which could not occur over large areas at the bottom of the muddy sea, in which according to this view the icebergs were drifted.

The conformation of the ground around Sudbury is of such a nature that it is extremely difficult to account for the stranding of icebergs in some of the spots where the contorted drifts occur, as, for instance, at the bottom of the Stour valley.

We come now to the last suggested cause of the production of contortion, viz. by the passage of land-ice. This agency is considered by Mr. Searles V. Wood, jun. (Q.J.G.S. vol. xxxvi. p. 479), to have produced the Chalky Boulder-clay with which the so-called Upper Boulder-clay of this district is identified. The map No. 4 of Mr. Wood (Q.J.G.S. vol. xxxviii. plate xxvi.) shows the ice which produced this clay blocked by the British ice to the north, and spreading over East Anglia parallel with the southern trend of this clay, *i.e.* in a general east and west direction. Could not such a mass of ice produce all the phenomena which are observable in the Sudbury area? The difficulty of accounting for the undisturbed state of the Tertiary rocks disappears at once upon this view. If the area over which the ice passed was a land-surface, it would be frozen so hard that the now incoherent rocks would be solid, and would be treated in a similar way to the harder rocks of other districts. Such seems to be the case. We find a series of ridges having a general E.—W. trend, composed of Crag sands, with intervening depressions sometimes cut deeply into the Chalk, as in the case already referred to, and figured by Mr. Whitaker. These ridges would be veritable *roches moutonnées*, which accords well with the appearance presented by that on Balingdon Hill. The fragments torn off and included in the drifts, being frozen, would not be crushed, but retain their form of large and small subangular boulders, such as that seen in Mr. Green's pit. Only on this view is the regular bedding of the torn Tertiary beds comprehensible.

Next, the contortion of the drifts, the relationship of the folds to the inequalities below, the large quantities of local material which enters into their composition, and the absence of marine organisms, is satisfactorily explained upon this supposition. I have already referred to the similarity of the divisional planes to those of the fluxion-structure of igneous rocks, which is not to be confused with the fluxion-structure described by Mr. Hugh Miller (Rep. Brit. Assoc. 1884, p. 720) as occurring in Till. Moreover, the great overfolds in the drift, as above remarked, seem to require the occurrence of considerable lateral pressure to produce them. That lateral pressure does produce a similar structure in the stratified deposits of land-ice is apparently indicated by the case figured in the "Meddelelser om Grönland," part iv. pl. iii., where a glacier ending in a narrow valley has its stratified sand and clay thus overfolded where the ice has been compressed against the sides of the valley. That this sand and clay may be interstratified with Boulder-clay produced by the same

agent as the bedded deposits is shown in a figure on the next plate of the same work, where a mass of Boulder-clay overlies such materials in the ice. The *moraine profonde* (including under this term all the drifts carried at and towards the base of the ice, whether derived from upland districts, or caught up from an ancient sea-floor over which the ice passed) coming from the flat tracts of the extreme East of England and the North Sea would be driven through the lateral valleys of the Sudbury area, and compressed laterally owing to the smaller space necessarily occupied by the lower parts of the ice under these circumstances. In this manner the contortion would be produced, accompanied by the small faults which are so common in these drifts, and so difficult to account for except upon the view that the drifts were solid at the time of faulting. Upon the melting of the ice, the drifts of this moraine,—Boulder-clays, gravel, and loam,—would be left standing upon the undisturbed beds of the irregular floor, once frozen, but resuming their incoherent condition upon the passing away of the cold.

In this way, and apparently in this way only, can we account for the phenomena of the Sudbury district, and the explanation has the advantage that it brings into play an agent which we know, from the researches of the Danish explorers upon the Greenland ice, does produce similar features at the present day, whereas all other explanations require the operation of agents, whose asserted mode of procedure is purely hypothetical.

V.—Notes on Chelonia from the Purbeck, Wealden and London-clay.

By R. Lydekker B.A., F.G.S., and G. A. Boulenger, F.Z.S.

Introductory.—The writers having had occasion, in company with Mr. Davies, to examine the greater number of the remains of English fossil Emydine and Pleurodiran Chelonia in the collection of the British Museum, with a view both to their rearrangement in the cases and the determination of their affinities, and having in the course of such examination been enabled to add several genera to the British fauna, as well as to make certain emendations in regard to the age and affinity of some of the previously-described forms, have thought it advisable to put their observations on record. Several of these observations are, indeed, only supplemental to those already published by Prof. Rütimeyer, of Basle, in the invaluable memoirs quoted below, but the writers have been able in some instances to add to his conclusions, owing to facts with which the learned Professor was necessarily unacquainted.

The reference by M. Dollo, of the Brussels Museum, of three of the Lower Eocene English species described by Sir R. Owen under the generic name of *Chelone* to a distinct genus *Pachyrhynchus*, has been already noticed by one of the present writers in last year's volume[1] of this Magazine. The term *Pachyrhynchus* is, however,

[1] Page 521. I must apologize to M. Dollo for having in this notice misinterpreted him as retaining Prof. Cope's family *Propleuridæ*. In the same notice I have quoted English forms under the generic names assigned to them by Owen, not having at that time entered on the question of the correctness of their determinations.—[R. L.]

preoccupied; and Prof. Cope had previously applied the generic term *Puppigerus* to several of Owen's species; some of which may, however, belong to other North American genera.[1] At least one of the carapaces of the Chelonians from the London Clay has nine costal bones, which is a character of Cope's *Propleuridæ*.[2] This group does not, however, form the proper subject of the present communication.[3]

Purbeck and Wealden.—The first genus for consideration is *Pleurosternum*, in which there appears a considerable amount of confusion. In their 'Monograph of the Chelonian Reptilia of the London Clay' (Pal. Soc. 1849) Owen and Bell figured in pl. xxi. a Chelonian plastron under the name of *Platemys Bullocki*, the specific name[4] dating from 1842. This specimen, now in the British Museum, is characterized by the presence of a mesoplastral bone, and also by an intergular epidermal shield. Owing to the former feature Prof. Rütimeyer[5] pointed out that the specimen could not have belonged to *Platemys*, but must be referred to the genus *Pleurosternum* of the Purbeck; he was, however, necessarily unaware that the specimen is really from the Purbeck, and not from the London Clay as stated by Owen and Bell. A comparison of this plastron with other Purbeck examples of *Pleurosternum* shows that it cannot be distinguished from the form figured by Owen in his Purbeck and Wealden Reptilia (Mon. Pal. Soc. 1853) under the name of *Pleurosternum ovatum*, with which the specimen figured in pl. vii. under the name of *P. emarginatum* appears also specifically identical; under these circumstances the name *Pleurosternum Bullocki*, as being the earliest, must be adopted for the common Purbeck form.[6] It should further be observed that it has been stated by Prof.

[1] See Amer. Nat. vol. xx. p. 968 (1886).

[2] Cope (*loc. cit.*) states that his *Propleuridæ* is identical with Dollo's *Pachyrhynchidæ*. The type species of the latter is, however, expressly stated to have only eight costals, which Cope makes a character of *Puppigerus*.

[3] It is usual among English writers to term the bony parts of the Chelonian shell "plates," and the horny epidermal covering "scutes"; but Prof. Huxley, "Anatomy of Vertebrated Animals," 1st edition, pp. 197, 200 (1871), uses the former term for both. Since, however, the term "scute" is applied to the dermal bones of the Crocodilia and of the Armadillos (*vide* Huxley, *op. cit.* pp. 250, 338), which are homologous with some of the bony elements of the Chelonian shell, this use is certainly objectionable; and in previous works I have reversed the application of the two terms. This application is not, however, thought advisable by Mr. Boulenger, who usually employs the terms in their older sense; as a compromise, in the present paper the bony elements will therefore be alluded to as "bones," and the elements of the epidermal layer as "shields."—[R. L.]

[4] Rep. Brit. Assoc. for 1841, p. 164 (1842).

[5] Verh. Nat. Ges. Basel, vol. vi. p. 121 (1873).

[6] Specimens of Purbeck Chelonia in the Cambridge Museum have been referred by Prof. Seeley (Index to Aves, Ornithosauria, etc., in the Cambridge Museum, pp. 86, 87 [1869]) to *Pleurosternum*, under the names of *P. Sedgwicki*, *P. Vansittarti*, *P. Oweni*, and *P. typocardium*. These specimens have, however, not been figured, and cannot therefore be compared with those in the British Museum; some of them may perhaps belong to *Plesiochelys*, while the distinction of others from *P. Bullocki* is not clear.

Cope[1] that the plastron of *Pleurosternum* has no intergular shield,[2] and the genus is accordingly referred by him to the Cryptodira; whereas its true position, as was pointed out by Prof. Rütimeyer, is with the Pleurodira; and with that group—the *Pelomedusidæ* and *Peltocephalidæ* of Gray—characterized by the presence of eleven, instead of nine, plastral bones.

With regard to the carapace figured by Sir R. Owen in pl. iv. of his "Wealden and Purbeck Reptilia," under the name of *Pleurosternum emarginatum* (of which it is the type), it appears from the emargination of the anterior border that the specimen does not belong to that genus at all; and it is highly probable that it should be referred to *Plesiochelys*, although, as only the ventral aspect of the carapace is visible, this cannot be definitely determined; the other specimen figured by Sir R. Owen under the same name cannot apparently be distinguished from *Pleurosternum Bullocki*. Another carapace from the Purbeck has been figured by Sir R. Owen in pl. i. of the above-mentioned work under the name of *Pleurosternum latiscutatum*, which differs from *P. Bullocki* by the notch in its anterior border, in the presence of a nuchal epidermal shield, and in the narrowness and length of the neural (vertebral) bones. A specimen of both carapace and plastron in the Museum (No. 23624) from the Wealden, which is evidently specifically identical, shows that there was no mesoplastron, and the species may apparently therefore be referred to the genus *Plesiochelys*.[3] A second English species of that genus is indicated by an imperfect shell from the Wealden in the collection of the Museum (No. 28967) which evidently belongs to the group containing the Upper Jurassic *P. Soluthurnensis* and *P. Sanctæ-Verenæ* of Rütimeyer,[4] and agrees so closely with the latter that it may apparently be referred to the same species; a younger shell of the species (No. R. 583) from the Wealden near Hastings is also contained in the collection. Two plastra from the Purbeck (No. 45937) have a large central vacuity, and thereby agree with *P. Etalloni*, Rütimeyer.[5] Prof. Rütimeyer[6] has already observed that the fragmentary remains from the Wealden figured by Sir R. Owen[7] under the name of *Platemys* and *Chelone costata* do not belong to those genera, and he has suggested that they may be Thallasemydians, but there seems no reason why they should not be referred to that group of *Plesiochelys* in which there is a large plastral vacuity. The occurrence in the English Wealden and Purbeck of several species of *Plesiochelys* apparently closely allied to those of the Upper Jurassic of the Continent is a matter of considerable interest.

[1] Proc. Amer. Phil. Soc. 1882, p. 143.

[2] The presence of an intergular shield is distinctly mentioned on page 5 of Owen's "Wealden and Purbeck Reptilia," although it is not shown in a complete state in any of the figured specimens.

[3] Mr. Boulenger takes this view.—[R. L.]

[4] Neue Denks. schweiz. Ges. Nat. vol. xxv. pls. xii. xiii.

[5] *Ibid.* pl. xi.

[6] Verh. Nat. Ges. Basel, *op. cit.* p. 166.

[7] Wealden and Purbeck Reptilia, pls. viii. and ix.

A crushed and broken shell with several of the bones of the pectoral and pelvic girdles, obtained by the late Mr. Fox from the Wealden of Brook, in the Isle of Wight, and now preserved in the Museum (No. R. 171), together with another crushed specimen (No. 48349) from the Wealden, and the anterior portion of a plastron (No. 46325) from the Purbeck, belong to the genus *Tretosternum*, and enable us to arrive at a conclusion as to the affinities of that genus. These specimens show, moreover, that the Chelonian remains from the Wealden of Bernissart in Belgium, described by M. Dollo,[1] under the name of *Peltochelys Duchastelii*, are not separable from the English *Tretosternum Bakewelli* (Mantell[2] sp.). M. Dollo was led to separate the Belgian form because Sir R. Owen[3] has suggested that *Tretosternum* may have had incomplete marginals; which the present specimens show is not the case. The suggestion of Sir R. Owen[4] that *Tretosternum* had a permanent plastral vacuity is shown by these specimens to be incorrect, although a small one exists in the young. M. Dollo places the genus in the Pleurodira, a view which is not supported by the examination of the remains in the Museum.

As may be seen from M. Dollo's figure, and still better from the Museum specimens, the anterior border of the nuchal bone is broadly emarginate, a character which occurs in none of the *Pleurodira*, for the reason that the head takes shelter on the side; but is found in all Cryptodira in which the head is particularly large and non-retractile, with the temporal fossæ roofed over by bone, as in *Chelydra*, *Platysternum*, *Chelone*, etc. Another peculiarity shown by the nuchal before us lies in the presence of a costiform process on each side, as in *Chelydra*; a process which, judging from Dollo's figures, is also shown in the young specimens from Bernissart. Important again is the fact, shown by our specimens, that the plastron articulates with the carapace by gomphosis, exactly as in *Chelydra*, and does not send off any axillary and inguinal peduncles like those so highly developed in all known Pleurodira. The plastron is essentially of the *Dactylosternine*-type of Cope. M. Dollo has, it is true, recognized the presence of an intergular shield, a character which has hitherto been regarded as infallibly diagnostic of the Pleurodiran group; this shield is also well shown in the type-specimen of *Tretosternum*. A careful examination shows, however, that this intergular is, in addition to only five pairs of plastral shields, exactly as in

[1] Bull. Mus. R. Hist. Nat. Belg. vol. iii. p. 78 (1884). The name itself is not very happily selected, since Prof. Seeley (Quart. Journ. Geol. Soc. vol. xxxvi. p. 412, 1880), has proposed the name *Peltochelyidæ* for an entirely different group of Chelonia.

[2] Geology of S.E. of England, p. 255 (1833)—*Trionyx. Tretosternum punctatum*, Owen, dates from 1842.

[3] Rep. Brit. Assoc. for 1841, pp. 165–7 (1842). Sir R. Owen's words are, "The entire and rounded margins of the truncated and expanded extremities of the ribs, beyond which there is not the slightest trace of projecting tooth-like processes, strongly indicates that the marginal plates [bones] were either wanting or rudimental, as in the genus *Cryptopus* [*Trionyx*]."

[4] *Op. cit.* p. 167. The generic name was given upon the assumed existence of this feature; since, however, the vacuity occurs in the young, no reasons can be adduced for changing the name.

certain specimens of *Dermatemys*, instead of the six pairs of all recent Pleurodira; and we think too great importance has hitherto been attached to the disposition of the epidermic plastral shields, as is shown by a specimen of *Macroclemmys Temminckii* in the Museum, which exhibits an intergular shield situated within the margin of the plastron, exactly as in the Australian *Chelodina*. Again, the number of plastral shields of *Tretosternum*, viz. 11, is that of a Cryptodiran, and not of a Pleurodiran. In addition to the above arguments, the remains before us give elucidation on a point which is in itself decisive; *viz.* the attachment of the pelvis. Two bones only are preserved, but they will suffice for our purpose; these are a sacral vertebra and a pubis. The former bone shows a large articular surface for a sacral rib, which was therefore present, and gave attachment to the ilium. In the Pleurodira, in which the ilium anchyloses with the carapace, sacral ribs are either atrophied or disappear altogether in the adult. The pubis, of a rather peculiar shape, owing to the great elongation and distal expansion of the inner or symphysial branch, is intact and shows that the extremity of the outer process was thin and compressed, and did not anchylose with the plastron.[1]

In the absence of any remains of the caudal vertebral column, it is impossible to say for certain that *Tretosternum* belongs to the family *Chelydridæ*, but we may surmise that such was probably the case. As far as can be judged from a comparison with Leidy's figure of *Anostira*, the two genera were very closely allied.

The last of the Chelonians from the Wealden and Purbeck that we have to notice is a small cordiform carapace from the latter formation (B. M. No. 40676), which may confidently be referred to the Thallasemydes of Prof. Rütimeyer (*Eurysternidæ* of Dollo), and may probably be referred to the genus *Eurysternum*.[2]

London Clay.—The first specimen from this formation that calls for notice is the hinder portion of a carapace in the Museum (No. 40099), which evidently belongs to the genus *Pseudotrionyx*, Dollo,[3] from the Middle Eocene (Bruxellian) of Belgium, and is apparently specifically identical with the typical *P. Delheidi*, Dollo. This genus is included by its founder in the *Chelydridæ*, but from the absence of epidermal shields may probably be regarded as belonging to a distinct family.[4]

The next species for notice is founded on the shell figured by Owen and Bell[5] under the name of *Platemys Bowerbanki*;[6] in regard

[1] On this occasion it may be well to observe that Rütimeyer's statement, made with due reserve, but since repeated by others as an admitted fact, that, in some recent *Pleurodira*, the ischium anchyloses with the plastron before the pubis, was derived from the examination of figures accompanying one of Gray's memoirs; and that an investigation of the actual specimens which gave rise to this statement has proved it to be erroneous.—[G. A. B.]

[2] = *Acichelys* = *Aplax* = *Palæomedusa* = *Achelonia* = *Euryaspis* = *Parachelys*.

[3] Bull. Mus. R. Hist. Nat. Belg. vol. iv. p. 96 (1886).

[4] The suggestion made in the above-quoted notice in the Geological Magazine that the genus might perhaps be referred to the *Trionychidæ* will not hold.—[R. L.]

[5] Reptilia of the London Clay, pt. i. pl. xxiii.

[6] Rep. Brit. Assoc. for 1841, pp. 163 (1842).

to which Prof. Rütimeyer [1] has already pointed out that the specimen figured by the same writers [2] under the name of *Emys lævis* is merely the young of the former, and that owing to the presence of a small mesoplastral bone the reference to *Platemys* is incorrect, and it is suggested that the species may probably belong either to *Podocnemis* or *Peltocephalus*. The type is unfortunately not in the collection of the Museum, but the figure shows that the length of the bony union between the carapace and plastron is comparatively long, from which its affinity appears to be rather with the former than the latter, and it may accordingly be provisionally referred to that genus.

With regard to the large Chelonian figured by Owen [3] under the name of *Emys Conybeari*, which appears specifically identical with the younger specimen figured as *Emys Delabechi*, Bell,[4] Professor Rütimeyer [5] has observed that it is difficult to say whether these forms belong to the *Emydidæ* or the *Chelydidæ*, but this difficulty has now been decisively solved. The best preserved and larger of the two specimens, or that figured under the name of *E. Conybeari*, shows both carapace and plastron, and exhibits in the latter distinct mesoplastral bones like those of *Podocnemis*. The matrix between the carapace and plastron has recently been chiselled away, and the characteristic Pleurodiran anchylosis of the ischium and pubis to the plastron is thus exhibited. In the number of the neural (vertebral) bones, in the flatness and general contour of the carapace, in the shape of the plastron and the relative length of the bridge uniting the latter with the carapace, and in the absence of a nuchal epidermal shield, the specimen accords so well with *Podocnemis*, that it may be pretty safely referred to that genus, under the name of *P. Delabechi*. The presence of two epidermal pygal shields differentiates it from the allied genus *Peltocephalus*; the vertebral shields agree in form very closely with those of *Podocnemis Dumeriliana*, although the contour of the carapace accords more closely with that of *P. expansa*. With regard to the so-called *Emys bicarinata* [6] from the same formation, a cutting-away of the matrix shows no trace of the pelvis, which was probably, therefore, of the Cryptodiran type, and the species may accordingly, in the absence of any evidence to the contrary, be included in the genus *Clemmys*. The occurrence of *Podocnemis* in the London Clay indicates that the *Pleurodira*, which are now almost entirely relegated to the Southern Hemisphere, were dominant forms at that period in the European area, as they also were in the corresponding epoch in India, where there were representatives of both *Podocnemis* and *Platemys* in the Lower Eocene.[7]

[1] Verh. Nat. Ges. Basel, p. 121.
[2] *Op. cit.* pl. xxii.
[3] Reptilia of London Clay, Supplement, pls. xxviii. A, B.
[4] *Ibid.* pl. xxviii.
[5] Verh. Nat. Ges. Basle, *op. cit.* p. 121.
[6] Owen and Bell, Reptilia of the London Clay, pt. i. pls. xxv. xxvi.
[7] These species will be described in a forthcoming memoir in the "Palæontologia Indica," ser. 10, vol. iv. pt. 3.—[R. L.]

REVIEWS.

1.—Professor Dr. Hermann Credner on the Development of Branchiosaurus.[1]

IN this valuable communication to Palæontological science Prof. Credner gives us the result of his observations on the life-history of a single species of Labyrinthodont, or Stegocephalian, based on the study of no less than 76 specimens.

The paper commences with a discussion of nomenclature and synonymy; but here we regret to say that we cannot quite agree with the author's conclusions. Prof. Credner states that in 1881 he described the skeleton of a small Labyrinthodont from the 'Rothliegendes' of Saxony under the name of *Branchiosaurus gracilis*, while on a subsequent page of the same memoir he described a second specimen as *B. amblystomus*. Subsequent 'finds' showed that the former is but the larval condition of the latter, and Prof. Credner proposes to adopt the name *B. amblystomus* for the species. He proceeds, however, to mention that Messrs. Geinitz and Deichmüller have pointed out that *B. gracilis* is probably identical with *Protriton petrolei* of Gaudry, from the Permian of France and Thuringia, and he therefore concludes that the latter is also a larval form, of which the adult may be perhaps still unknown, or may be the so-called *B. amblystomus*. So far no objection can be taken to Prof. Credner's views; but when he proceeds to observe that the name *Protriton petrolei*, as being founded on a larval form, ought to be withdrawn, we cannot agree with him. There appears, indeed, to be no doubt that Messrs. Geinitz and Deichmüller are right in regarding *Branchiosaurus* and *Protriton* as generically the same, and there is also a very strong presumption that *B. gracilis* (*B. amblystomus*) and *P. petrolei* are also specifically identical. Now the generic name *Protriton* was first published (with figures of the type specimen) by Gaudry in the "Bull. Soc. Géol. France," sér. 3, vol. iii. p. 300 (March 29, 1875); the type specimen having been previously recorded under the name of *Salamandrella petrolei* in the "Comptes Rendus," vol. lxxx. p. 442 (Feb. 15th, 1875), the earlier generic name being withdrawn on account of being pre-occupied. The term *Branchiosaurus* was first published by Fritsch in the "Sitz. k. bohm. Ges. Wiss." (19th March, 1875),[2] p. 72; but was not figured till 1879, in the "Fauna der Gaskohle," etc., pt. 1, p. 69, pl. i.–iv. The generic name *Protriton* is therefore, strictly speaking (if we count from the date of the reading of the memoir), of ten days' later date than *Branchiosaurus*; but since the date of figuring gives no less than four years' advantage on the side of the former, we think that the generic name *Protriton* ought

[1] "Die Stegocephalen aus dem Rothliegenden des Plauen'schen Grundes bei Dresden," VI. Theil.—Zeitschr. deutsch. Geol. Ges. pp. 576–633, pls. xvi.–xix. (1886).

[2] Fritsch (Fauna der Gaskohle, etc., pt. i. p. 69 [1879]) totally ignores his previous preliminary notice of the genus, and expressly states that it should date only from the time of figuring (1879).

to stand; and if *P. petrolei* be identical with *B. gracilis*, there can be no question as to the right of the former specific name to supersede the latter.

Coming to the proper subject of the paper under consideration, it appears that the youngest specimen which came under the author's notice was about 25 mm. in length. In this stage the animal was aquatic, and breathed by gills, which were supported by four pairs of branchial arches. The cartilaginous dorsal segments of these arches were furnished with small calcified denticules; and the ventral segment of the first was ossified. By the time, however, these animals had attained a length of from 60 to 70 mm., they cast their branchial arches and became air-breathers; their development being thus analogous to that obtaining among the *Salamandridæ* of the present day. The adults measure from 100 to 130 mm. in length.

This metamorphosis from a water- to an air-breather was accompanied by the following changes in the structure of the skeleton. The short and wide skull of the larva becomes relatively narrower; the proportion of the transverse to the longitudinal diameter being 2 to 3 in the larva, whereas these two diameters in the adult are subequal. The relative increase in length is mainly confined to the anterior cranial bones; and the orbits, and more especially the parietal foramen, do not enlarge at the same rate as the surrounding bones. In the pectoral-girdle,[1] while the coracoid and supra-clavicle only increase in size proportionately with the general growth of the animal, the median element (interclavicle) of the ventral buckler, which is very minute in the larva, attains a length of 8 or 9 mm. and forms a pentagonal bone, interpenetrated by slits from the anterior border. The lateral bones (clavicles) of the shield in the larva are small and in contact with each other in the median lines; but as development advances they become relatively broader, and separate. In the vertebral column it has been found that while in the larva the presacral vertebra are 20 in number, they are 26 in the adult, this being accompanied by a diminution in the relative length of the tail in the former. This remarkable change Prof. Credner explains by a gradual backward shifting of the pelvis as the animal increases in age, from which it necessarily follows that the sacral vertebra of the larva become lumbar in the adult. With the lengthening of the presacral vertebral column the bones of the limbs do not keep pace; so that the limbs of the adults are relatively much shorter than those of the larva. During the above-mentioned changes the dermal and epidermal skeleton is likewise undergoing evolution; and in the adult the ventral surface of the body is protected by a complete and complex covering of dermal scutes, of which the author has succeeded in tracing out the arrangement; while in the young larva this covering is totally wanting.

Prof. Credner is indeed to be congratulated on having traced in

[1] Prof. Credner employs a nomenclature of the elements of the shoulder-girdle different from that adopted by many writers; but the equivalent terms are noticed on p. 607 of his memoir. In this notice we employ the terms used in the "British Association Report" on the Labyrinthodontia.

this able and interesting manner the development of a water-breathing naked larva of the Palæozoic epoch into an air-breathing adult, clad in a strong coat of mail; and we shall welcome with much interest future work on kindred subjects. R. L.

II.—On Certain Borings in Manitoba and the North-west Territory. By George M. Dawson, D.Sc., A.R.S.M., F.G.S. [From the Transactions of the Royal Society of Canada, vol. iv. 1886.] Montreal, 1887.

VARIOUS useful purposes are subserved by boring operations, such as the procuring a supply of pure water in arid regions; the search for useful minerals, petroleum, etc., in which case boring may be regarded as an expeditious, and, upon the whole, economical method of prospecting; and finally, as a means of gaining a knowledge of the nature of the subjacent strata when these are concealed by drift deposits.

We shall dwell more particularly upon the results of these borings from the geological standpoint, as being that which is most likely to interest the readers of this Magazine.

We have then 1, "Boring at Rosenfeld Station." This is a station on the South-Western Branch of the Canadian Pacific Railway, about fifteen miles north of the 49th parallel and ten miles west of the Red River Valley. In this boring, which was undertaken by the C. P. Railway Co., a depth of 1037 feet was attained by means of an ordinary percussion drill.

The nature of the beds passed through, with their probable geological age, is indicated in the accompanying slightly abridged section:

		Feet.	Formations.
1.	Black soil	4	
2.	Fine silt or clay	111	
3.	Sand and gravel	10	
4.	Boulder-clay ("hard-pan")	12	
5.	Boulders	6	
6 to 9.	Grey and red shales and limestone	92	Maquoketa shales.
10 to 13.	Limestone, sandstone, and red shale	260	
14.	Cream-coloured limestone	305	Galena limestone passing below into Trenton.
15.	Red shale	75	
16.	Soft sandstone	50	St. Peter Sandstone
17 to 20.	Red, green, blue, and grey shales	110	L. Magnesian limestone (?).
21.	"Granite"	2	Laurentian.
	Total	1037	

A detailed analysis here follows, which may be thus briefly summarized:—The soil was of the character common in that region, and consisted of the underlying silts mixed with vegetable matter. "The silts are those of the ancient lake which, about the close of the Glacial Period, occupied the Red River Valley, and which has been called 'Lake Agassiz' by Mr. Upham."[1] The gravel consisted of rounded Laurentian and limestone pebbles. "The 'hard-pan,'

[1] See Geological Magazine, 1883, p. 427, "Lake Agassiz; a Chapter in Glacial Geology," by Warren Upham.

while evidently representing the Boulder-clay, is unusually pale in colour, being apparently composed of limestone debris."

Passing on to the consideration of the beds underlying the drift, we learn that their geological age was considered by the author to be doubtful, owing to the entire absence of palæontological evidence or of any outcrops in the vicinity of the boring, by which the result of the operations might have been checked.

However, pretty strong presumptive evidence seems to have been elicited regarding the age of the beds supposed to represent the "Maquoketa shales," so named by Dr. C. A. White, in Iowa. In Iowa these shales are about 75 feet in thickness, and consist of bluish and brownish shales with calcareous layers. In Wisconsin, they average about 200 feet in thickness, and are composed of grey, green, blue, red, purple, buff and brown shales with thin limestones. These beds are met with also in Minnesota, but owing to the want of complete sections they could not be compared with those of the Rosenfeld boring. But at Stony Mountain, Manitoba, fifty-eight miles north, strata determined by their fossils to be of the horizon of the Hudson River were met with. A section made at this locality showed that the rocks consisted of dolomitic and other limestones, and red and yellow shales, resembling very closely those referred to the Maquoketa Shales (Nos. 10 to 13 in the section) in the Rosenfeld boring.

The limestone (No. 14) underlying the Maquoketa shales is assigned to the horizon of the Galena limestone of the west, which it was found to resemble in character; while the red shale at the base (No. 15) was supposed to be the equivalent of the Trenton.

"The Galena limestone of the West, which is nearly equivalent to the Utica of the New York series, is about 180 feet thick in Minnesota; 250 feet thick in Wisconsin; and from 100 to 250 feet thick in Iowa.

"The Trenton in Minnesota consists of flaggy limestones, with interbedded greenish shales, and is nearly 160 feet in thickness. In Iowa it consists of clayey shales and shaly and compact limestone, 200 feet in thickness. The reddish colours of the Rosenfeld shales and their apparently more complete separation from the limestone and want of interlamination with it, constitute the chief point of dissimilarity. The massive buff limestones of Selkirk and Stone Fort in Manitoba, resemble the Rosenfeld bed in character, and are known by the evidence of fossils to represent the Galena."

No. 16 in the section, an "unconsolidated sand-bed," is described as resembling precisely the "St. Peter Sandstone," as typically developed near St. Paul, Minnesota.

Assuming that the geological horizons of the preceding beds have been accurately determined, then it is held that beds 17 to 20 (both inclusive) must be referred to the "Lower Magnesian Limestone," equivalent in age to the Calciferous [Tremadoc] of the New York section. This limestone in Iowa and Wisconsin has a thickness of 65 to 250 feet. In Minnesota it is a magnesian rock, sandy towards the top, and with beds of greenish shale. At Rosenfeld there is no

limestone, and Dr. Dawson concludes, therefore, that we have here "a littoral formation directly overlying the subjacent Laurentian, and marking the limit at this place of the Lower Magnesian Sea."

The most remarkable feature of the Rosenfeld well was the strong flow of brine which issued from it, especially at the level of the St. Peter Sandstone, whence it rose in a pipe to a height of 18 feet above the surface of the ground. The author calls attention to the great age of the rocks yielding the brine. "It appears," he says, "not improbable that the shoaling of the Cambro-Silurian sea evidenced by the widespread littoral deposit known as the St. Peter sandstone resulted in the enclosure of salt lagoons in this portion of the interior basin, while it merely produced an increased land area further south in Iowa and Wisconsin."

The brine is said to be well adapted for the manufacture of salt.

Another fact of geological importance was elicited by the Rosenfeld boring, viz. "the comparatively thin covering of Palæozoic rocks which here overlaps the Archæan, and the very gradually shelving character of the surface of the latter westward."

Passing over the records of borings at various places (numbered 2 to 6) in which there appears to be nothing worthy of special note, we reach No. 7:—"Boring at Langevin Station."—This place is also on the line of the Canadian Pacific Railway, 35 miles west of Medicine Hat, on the South Saskatchewan River, at an elevation of 2471 feet above the sea-level. Two borings were made here, the one attaining a depth of 1155 feet, and the other 1400 feet. The result of these operations was somewhat unexpected, and, in the first case disastrous, a heavy flow of combustible gas having been discharged from the bore-hole, and this becoming ignited, destroyed the works at the surface. This boring had consequently to be abandoned, and another undertaken, the gas being now utilized for working the engine.

This second boring showed (1) Drift deposits, estimated at 88 feet in thickness; with (2) about 223 feet of beds consisting probably of the lower part of the "Belly River Series"[1] (Upper Cretaceous) underlying them. Beneath the latter there were found beds aggregating 1099 feet in thickness; these are considered by Dr. Dawson to be probably of the age of the "Lower Dark Shales,"[2] passing down into the "Fort Benton Group" (?) (Lower Cretaceous).

The result of the operations at Langevin proves the existence of a large quantity of combustible gas in the district; a matter of great economical importance. The supply of gas comes from the sandy layers of the "Lower Dark Shales" at depths of 900 feet and over, and is derived, in the opinion of the author, from the decomposition of the organic matter of the dark Carbonaceous shales.

ARTHUR H. FOORD.

[1] See Geol. Surv. of Canada, Report of Progress, 1882-83-84, p. 112*c*.
[2] *Loc. cit.* p. 42*c*.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 6, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Rocks of the Malvern Hills." Part II. By Frank Rutley, Esq., F.G.S.

The details of the microscopic examination of the rocks constituted the principal part of the present paper. The author finds that the truly eruptive rocks are more plentiful in the range than he was at first led to suppose. In all 33 rock-specimens were described, and in some cases Mr. Timmins's analyses were quoted. The author commenced with the rocks of the North Hill and concluded with those of the Raggedstone Hill. Rocks between a little south of the summit of the Worcestershire Beacon on to Wind's Point, those of Midsummer Hill, and those of Keys Hill were not collected. The following are the general results:—

	Eruptive.	Foliated.	Stratified.
North Hill	Hornblende-gabbro. Diorite. Quartz-syenite.	Gneissic Syenite. Gneissic Diorite.	Altered Tuff?
North Hill (above West Malvern).	Mica-diorite.	Biotite-gneiss.	
North Hill (The Dingle).....	Mica-diorite.		
Worcestershire Beacon	Granulite?		
	Granite. Diorite. Epidotite?		
Herefordshire Beacon.....	Eucrite.	Hornblendic Gneiss.	Diabase-tuff?
	Basalt. Devitrified Obsidian.		
Swinyard's Hill..	Pegmatite. Hornblende-pegmatite Diorite.	Biotite-gneiss. Biotite-muscovite. Gneiss.	
Hollybush Pass...	Diabase.		[stone.
Raggedstone Hill.	.....	Mica-schist. Micaceous Quartzite-schist.	Altered Sand-

In the first instance a separation must be effected of rocks showing foliation or lamination, or of which the origin has been sedimentary, from those which show no such structure, and which must be regarded as eruptive: there is, in fact, a banded and an unbanded series. The gneisses are altered volcanic tuffs or sedimentary rocks of eruptive material derived from the disintegration of rocks of dioritic or syenitic character.

The rocks of the North Hill, as may be gathered from the tabular classification, are truly eruptive in many cases; whilst the foliated varieties are made up of the *débris* of rocks rich in hornblende, which may have had an eruptive origin. The rocks of the Here-

fordshire Beacon are chiefly gneissic: the eucrite-basalt occurs at a buttress of the hill. The pegmatite of Swinyard's Hill has apparently been faulted into its present position. South of Midsummer Hill fine-grained gneissic rocks, quartzite-schists, etc., are met with.

There is no reason to suppose that the alteration of any ordinary sedimentary rocks could have resulted in such a vast amount of hornblende as is found in these gneisses. The gneissic rocks of the Malvern Hills may be composed of the detritus of eruptive rocks.

The rocks of the Malvern Hills show in their structure but little resemblance to the foliation induced by shearing, the crystals seldom exhibiting any marked lenticular form, while there is but little likeness to the pseudo-fluxion structure described by Lehmann, etc.

The author concluded that the rocks of the Malvern Hills represent part of an old district consisting of plutonic and, possibly, of volcanic rocks associated with tuffs, sedimentary rocks composed mainly or wholly of eruptive materials, and grits and sandstones; that the structural planes in these rocks (sometimes certainly, at others possibly) indicate planes of stratification, and that the foliation, in many cases if not in all, denotes lamination due to deposition either in water or on land surfaces, probably more or less accentuated or altered by the movements which produced the upheavals, subsidences, and flexures prevalent in the range.

2. "On the alleged Conversion of Crystalline Schists into Igneous Rocks in County Galway." By C. Callaway, Esq., D.Sc., F.G.S.

This paper was an inquiry into the theory, held by many Irish geologists, that granite and other igneous rocks are the last term in a progressive series in the metamorphism of aqueous sediments. The evidence collected by the author was regarded as entirely hostile to this view. In Knockseefin, the typical section, he found diorite intrusive in gneiss and granite intrusive in the diorite, but no passage between any two. The igneous veins sometimes displayed a foliated structure. At Shaunarea the phenomena were similar; but the granite in contact with the gneiss was much crushed and decomposed. In the region south of Glendalough the intrusion of granite in diorite and schist gave rise to the peculiar mixtures which had been described as "metamorphosed conglomerate." The granite was intruded along the joints of the diorite, sometimes separating the joint-blocks from each other, and completely enclosing them. It was noticed that when schists were penetrated by granite isolated folia often retained their parallelism, and this was accounted for partly by the slowness of the intrusion, partly by regional pressure. Even when mere flakes of the schist were enclosed in granite there was no passage between the two. The granite, both in masses and veins, was often foliated, but the blocks of included diorite were not; and this seemed to suggest that the foliation of the granite was acquired before complete congelation of the larger masses. There was also a foliation concentric to included blocks of diorite.

At the town of Galway the "metamorphic sedimentary" rocks were a coarse-grained hornblendic gneiss of Hebridean aspect, and in some parts of it was a structure similar to that of the "metamor-

phosed conglomerate"; but the included blocks of diorite had acquired a definite orientation, apparently due to pressure. An igneous origin for some of the coarser gneisses was thus suggested. It was concluded that there was no proof of the conversion of schists into igneous rocks, the evidence collected tending to show, on the other hand, that igneous rocks were sometimes converted into schists.

3. "A Preliminary Inquiry into the Genesis of the Crystalline Schists of the Malvern Hills." By C. Callaway, Esq., D.Sc., F.G.S.

The author's researches amongst the crystalline rocks of Connaught had suggested certain lines of investigation which had subsequently been followed out in the Malvern district. He had satisfied himself that many of the Malvern schists had been formed out of igneous rocks; but at present he limited himself to certain varieties.

The materials from which these schists were produced were diorite (several varieties), granite, and felsite.

The metamorphism had been brought about by lateral pressure. Evidence of this was seen in the intense contortion of granite-veins and in the effects of crushing as observed under the microscope.

The products of the metamorphism were divided into two groups:—

A. Simple schists, or those formed from one kind of rock. The varieties described were the following:—*Hornblende-gneiss*, or diorite which had been crushed and modified. *Mica-gneiss*, formed from granite. In the first stage of the crushing, the quartz and felspar lay in lenticular fragments, separated from each other by cracks, the fragments and cracks being roughly parallel. As the metamorphism proceeded, the cracks became less evident, and the respective minerals were flattened out into comparatively uniform folia. Mica gradually came in, at first in the form of a partial coating to felspar crystals, and, at a further stage, in regular folia. *Mica-schist*, formed from felsite. The felsite gradually acquired a parallel structure. *Pari passu* with this mechanical alteration, a mineral change was observed. Mica at first appears in very small quantity, either filling cracks or accentuating the parallelism. In a more advanced stage, the mica lies in imperfect folia, and sometimes forms a partial coating to grains of quartz. At last there is little left but quartz and mica, the latter in folia, and enveloping individual quartz granules.

B. Injection schists, formed by the intrusion of veins, which had acquired parallelism by pressure. Veins of diorite in diorite produced *duplex diorite-gneiss*, and veins of granite in diorite originated *granite diorite-gneiss*.

It was further noted that

(1). Generally the particular varieties of schist occurred in the vicinity of the igneous masses to which they were most nearly related in mineral composition.

(2). The mineral banding of the rocks in the field was more like vein-structure than stratification.

The author accepted the received view of the age of the schists. The parallel structure was clearly antecedent to the Cambrian epoch, and the occurrence of similar rocks as fragments in the Uriconian

conglomerate of Shropshire seemed to indicate that the Malvernian schists were older Archæan.

II.—April 27, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the London Clay and Bagshot Beds of Aldershot." By H. G. Lyons, Esq., R.E., F.G.S.

The author first described the section from Thorn Hill on the N. to Redan Hill on the S., plotted from the 6-in. Ordnance Survey on a scale of 6 in. to 1 mile horizontal, and 12 in. to 1 mile vertical. This section comprises beds from the Woolwich and Reading series to the Upper Bagshot inclusive. He showed a dip of $2\frac{1}{4}°$ to the N. which is regular or nearly so throughout. A few feet of Upper Bagshots occur on Thorn Hill (365 feet); at the base of these the Pebble-Bed crops out, forming also much of the surface of the South Camp. The Middle Bagshots on the south slope of the hill are estimated from the South Camp boring at 53 feet, with a marked clay-bed at the base; and below these a few feet of the Lower Bagshots are exposed in the intervening valley. The greater part of Redan Hill (364 feet) is made up of Lower Bagshots; but towards the top a few feet of the basal clays of the Middle Bagshots have been exposed by a recent trench. Although the elevation is practically the same as that of Thorn Hill, the rest of the Bagshot series is cut out owing to the northerly dip. These results differ from those of previous observers, *e.g.* the Geological Survey carry the Lower Bagshots to the top of the Redan Hill, as do Messrs. Monckton and Herries; whilst of the anticlinal, alleged by Mr. Irving to exist in this traverse, there appears to be no trace. The author also observed that the arguments for overlap of the upper beds and for the erosion of the London Clay are not borne out by the facts.

The second section described runs from Gravel-Pit Hill on the N. to Ash Green on the S. It was drawn to the same scale, and showed the beds from the Chalk to the Middle Bagshots inclusive. Dip northerly $2\frac{1}{4}°$ to $2°$ 50′ at south end. A spur of the Fox Hills (Gravel-Pit Hill) is seen to consist of Upper Bagshots of the normal type down to the lower shoulder of the spur, which is capped by the Pebble-beds marking the junction of the Upper and Middle Bagshots. The Ash-station well shows the basement-beds of the Lower Bagshots, of a character very similar to those in the Brookwood and South-Camp deep boring. The position of the outcrop of the London Clay also is in favour of a regular and persistent northerly dip, corresponding in degree with that given at East Wyke farm by Messrs. Monckton and Herries. The thickness of the London Clay was calculated at 330 feet, which is about the same as at South Camp, leaving no margin for its erosion before the deposition of the Bagshots.—The third section was drawn, also on the same scale, through Aldershot town, showing the beds from the Woolwich and Reading series to the Middle Bagshots inclusive. The dip is $2\frac{1}{4}°$ to the N., and regular, as in the other two cases. The following thicknesses are given:—

Middle Bagshots	about 55 feet.
Lower Bagshots	,, 115 ,,
London Clay	,, 335 ,,

It was inferred from various calculations, as also from direct observation, that the thickness of the London Clay shows no diminution throughout the section, being nearly the same also at Ash and at Aldershot Place.

In "Cæsar's Camp" the Pebble-bed occurs at altitudes ranging from 500 to 550 feet.

The author concluded that wherever we can fix the top or base of the London Clay, we get a northerly dip of $2\frac{1}{4}°$ to 3°, showing a fairly constant thickness of from 330 to 340 feet. The same thing occurs from Odiham on the west to Ash on the east, whilst at Brookwood the London Clay is thicker. He also assumed the existence of a passage from the London Clay up into the Bagshot beds in the deep wells or borings at Wellington College, at Brookwood, and at South Camp. Hence at these points there can have been no great erosion or unconformity. The overlying Bagshots lie conformably on the London Clay and on each other.

2. "Supplementary Note on the Walton Common Section." By W. H. Hudleston, Esq., M.A., F.R.S., Sec.G.S.

The principal object of this paper was to point out the occurrence of certain beds of clay or loam in what are usually known as the "Lower Bagshot Sands" of West Surrey. It was shown that the sandy series, No. 3, of the previous paper is overlain by a second clay series, No. 4, whose mode of occurrence and lithology were described. This is again succeeded by a third sandy series, No. 5, which, it is believed, is maintained throughout the remainder of the cutting as far as the River Wey, with occasional clay patches deposited in small basin-shaped hollows of the sand.

The nature and geological position of the brick-earth of Hatch on Woburn Hill was next described. This forms a portion of the "clays most extensively developed between Addlestone and Chertsey," referred by Professor Prestwich to his Middle Bagshots, and mapped as such by the Geological Survey. The clay is seen to occur as a lenticular mass, 21 ft. thick at its maximum, in a hollow of loose yellow sand; the current-bedding of the upper loamy layers is very marked towards the north end, with a strong false dip to the south, *i.e.* towards the centre of the basin.

Accepting as the true datum line for the base of the Middle Bagshots in this district, "the foliated clays, more or less sandy, having a thickness of 14 ft.," which are shown by Prof. Prestwich to be typically developed in the railway-cutting on Goldsworth Hill, it was contended that the Hatch brick-earth cannot be correlated with these. The true basal beds of the Middle Bagshots in this district differ somewhat in their physical characters; but it was on stratigraphical grounds mainly that the author endeavoured to show that the Hatch brick-earth should, despite its argillaceous nature, be assigned to the Lower Bagshots. A diagrammatic section from St. George's Hill (245 ft.), through Woburn Hill (92 ft.), to St.

Ann's Hill (230 ft.), was given, and the possible existence of a trough or synclinal towards the centre of the section discussed. It was shown from the position of the Hatch brick-earth that if the Lower Bagshots retain anything like the mean thickness of, say, 120 ft., which prevails in this district, the London Clay surface must here be 60 ft. *below* O.D., on the supposition that these beds represent the basal clays of the Middle Bagshots; whereas, at Chertsey, in the valley of the Thames itself, the London clay surface coincides with O. D.

In conclusion, it was held (1) that the more we study the Bagshot beds of this area, the less likely are we to see a passage between the curiously diversified Lower Bagshots and the much more uniform and homogeneous London Clay; (2) that, until we realize the considerable though sporadic development of clays in the Lower Bagshots, we shall be in danger of referring beds to the Middle Bagshots which do not belong to them, and thereby give encouragement to a speculative stratigraphy which can only mislead.

III.—May 11, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Further Observations on *Hyperodapedon Gordoni*." By Prof. T. H. Huxley, LL.D., F.R.S., F.G.S.

The author briefly noticed the circumstances under which he first described the occurrence of Lacertilian and Crocodilian fossils in the Elgin Sandstones, and the confirmation which his views as to the Mesozoic age of these remains had received from the discovery of *Hyperodapedon* in English Triassic rocks and in India. The original type of *Hyperodapedon Gordoni* from Elgin was, however, in bad condition, and the receipt at the British Museum of a second much better preserved skeleton, found in the Lossiemouth quarries of the same neighbourhood, had enabled him to add considerably to the known characters of the genus, and to compare it more thoroughly both with the recent *Sphenodon* (or *Hatteria*) of New Zealand and with the Triassic *Rhynchosaurus articeps*, several specimens of which are in the British Museum palæontological collection.

The recently-discovered *Hyperodapedon*-skeleton was of nearly the same size as that formerly described, and must have belonged to an individual about 6 or 7 feet in length. The specimen was exposed by the splitting of a large block of sandstone, and comprised the skull, the vetebral column as far as the root of the tail, all the bones of the left and of part of the right fore limb, and those of the right hind limb, the whole almost in their original relations.

The bones were described in order and compared with those of *Sphenodon*, the most important differences in *Hyperodapedon* being the following:—

1. The centra of the presacral vertebræ are ossified throughout and more or less opisthocœlous, especially in the cervical region.
2. The anterior cervical vertebræ have long and strong ribs.
3. The external nares are not separated by bone.
4. Conjoined premaxillary bones form a long, conical, curved, pointed rostrum, which is received between the rostral processes of the mandible. All these were devoid of teeth and probably sheathed in horn.

5. The palatal area is very narrow in front and wide behind, with strongly curved lateral boundaries.
6. The posterior maxillary and palatal teeth are multiserial.
7. The rami of the mandible are united in a long symphysis, behind which they diverge widely, and the dentigerous edges are strongly concave upwards as well as outwards.
8. The mandibular teeth in front are set into a close, apparently continuous palisade, and become distinct and conical only at the posterior end of the series.
9. The fore foot is remarkably short and stout, with metacarpals of equal length.

The relations of *Rhynchosaurus* to *Hyperodapedon* and *Sphenodon* were then dealt with, the first-named being shown to occupy in some respects an intermediate place between the two others. The skull of *Rhynchosaurus* resembles that of *Hyperodapedon* in its single anterior nasal aperture, its premaxillary and mandibular rostral processes, and in having more than one series of palatal teeth; but in general form and in the shape of the maxillæ, palatal bones, and rami of the mandible, it departs far less from *Sphenodon* than *Hyperodapedon* does. Some comparisons of limb-bones were also made.

The three genera mentioned were shown to form a particular group, which, however, had no claim to ordinal distinction, and appeared to form a family, Sphenodontidæ, of the Lacertilia, comprising two subfamilies, Rhynchosaurinæ (including *Rhynchosaurus* and *Hyperodapedon*) and Sphenodontinæ.

The fact that in this Lacertilian group the highest known degree of specialization, as shown in *Hyperodapedon*, was attained as early as the Triassic epoch, showed that in Permian times, or earlier, Lacertilia existed which differed less from *Sphenodon* than either of the Rhynchosaurinæ did. Not only was the Lacertilian type of organization clearly defined in the Triassic epoch, but it attained a degree of specialization equal to that exhibited by any modern lizard.

2. "Rocks of the Essex Drift." By Rev. A. W. Rowe, M.A., F.G.S.

The rocks of the Essex drift are of great variety. There is a remarkable absence of granite of any kind, and only two specimens of syenite have been found. Quartz-porphyrites and quartz-tourmaline rocks are fairly abundant, felsites are rarely met with, but felspar porphyrites are very abundant; trachytes also are found, but there is some reason for suspecting that these do not really belong to the drift, but have been imported in very early times. The most abundant of the igneous rocks are the dolerites; but all the coarser dolerites and those of a true ophitic character are wanting. Many of the specimens are of subophitic texture, and bear a general likeness to the subophitic dolerites of Central England. Some specimens, however, are strikingly like the rocks of the Whin Sill, in certain special points. The dolerites of trachytic texture, or basalts, do not at all resemble those of the North of England, but some of them are almost identical with certain Scandinavian basalts. One or two specimens deserve special mention, and among them a hypersthene-bearing dolerite that is more nearly ophitic than any of the others. Two specimens of granulite containing hypersthene are interesting as belonging to a well-characterized type. The crystalline schists are

not abundant; among them is a hornblende schist containing abundance of tourmaline. The sandstones, some of which are of very large size, belong chiefly to the Carboniferous series, and, as a rule, are unfossiliferous. Two blocks of fossiliferous sandstone have been identified with the sandstone of the Lower Neocomian series in Lincolnshire. Of the limestones there are a great number of blocks of a hard grey crystalline limestone of the Carboniferous series containing some very perfect specimens of Foraminifera; and two specimens from the Rhætic beds, which are of peculiar interest if, as it is said, the Rhætic beds do not now come to the surface anywhere in the North of England. The greater number, however, of the limestones belong to the Jurassic series; there are also many lumps of very hard chalk which have been identified with the hard chalk of Cambridgeshire. The microscopic sections of the Chalky Boulder-clay show that amid grains of quartz, sand, etc., there are a great number of minute Foraminifera still wonderfully well preserved. The way in which the Chalky Boulder-clay and the gravels lie was well shown in a railway-cutting near Dunmow some short time ago, and happily a small photograph of the section was taken at the time, for that part of the cutting has now been covered in. It is possible that this attempt at classifying and describing the rocks of the drift may be of some assistance to those who are considering the general question of the glacial drift.

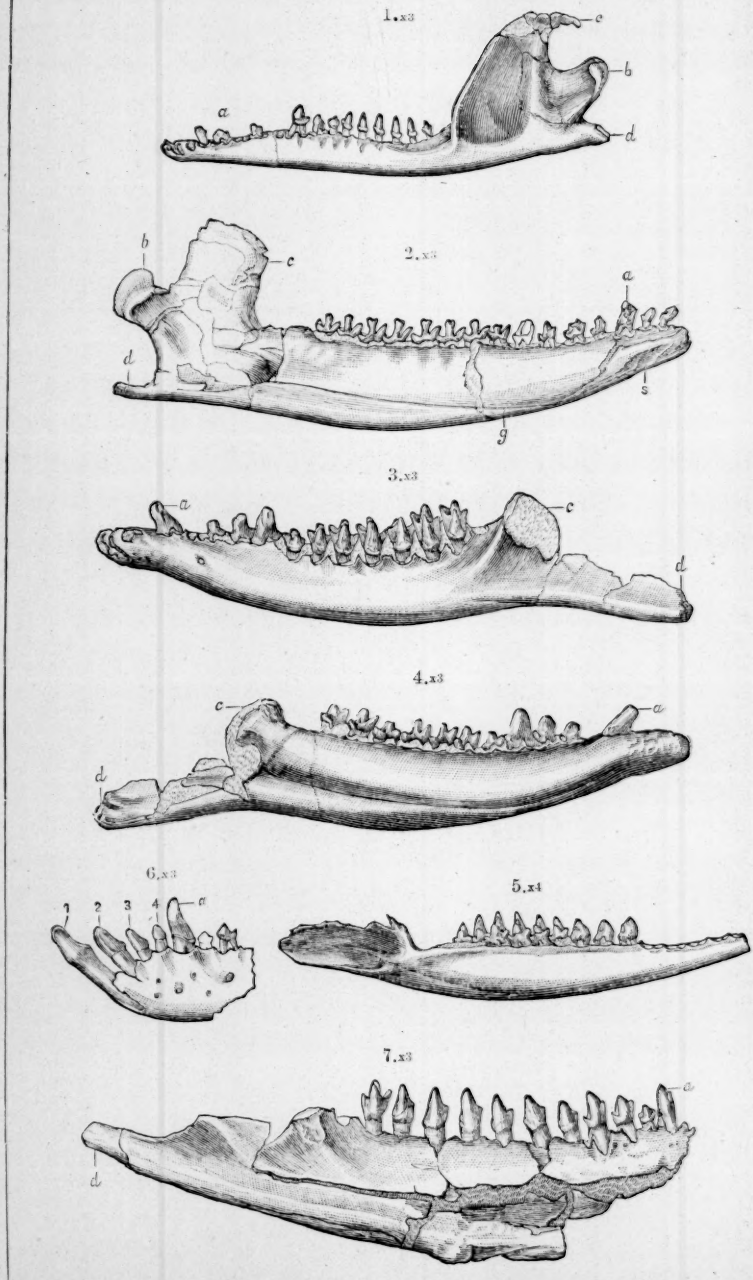
3. "On Tertiary Cyclostomatous Bryozoa from New Zealand." By Arthur W. Waters, Esq., F.G.S.

The Cyclostomata noticed in this paper were from the same collections as the Chilostomata described in the last volume of the Quarterly Journal, and this part was kept back a short time, in the hope that the publication of the Report of the "Challenger" expedition might throw some light upon this unsatisfactory suborder; but the results are very disappointing in this respect, as only thirty-three species are recorded, and these for the most part well known and common ones.

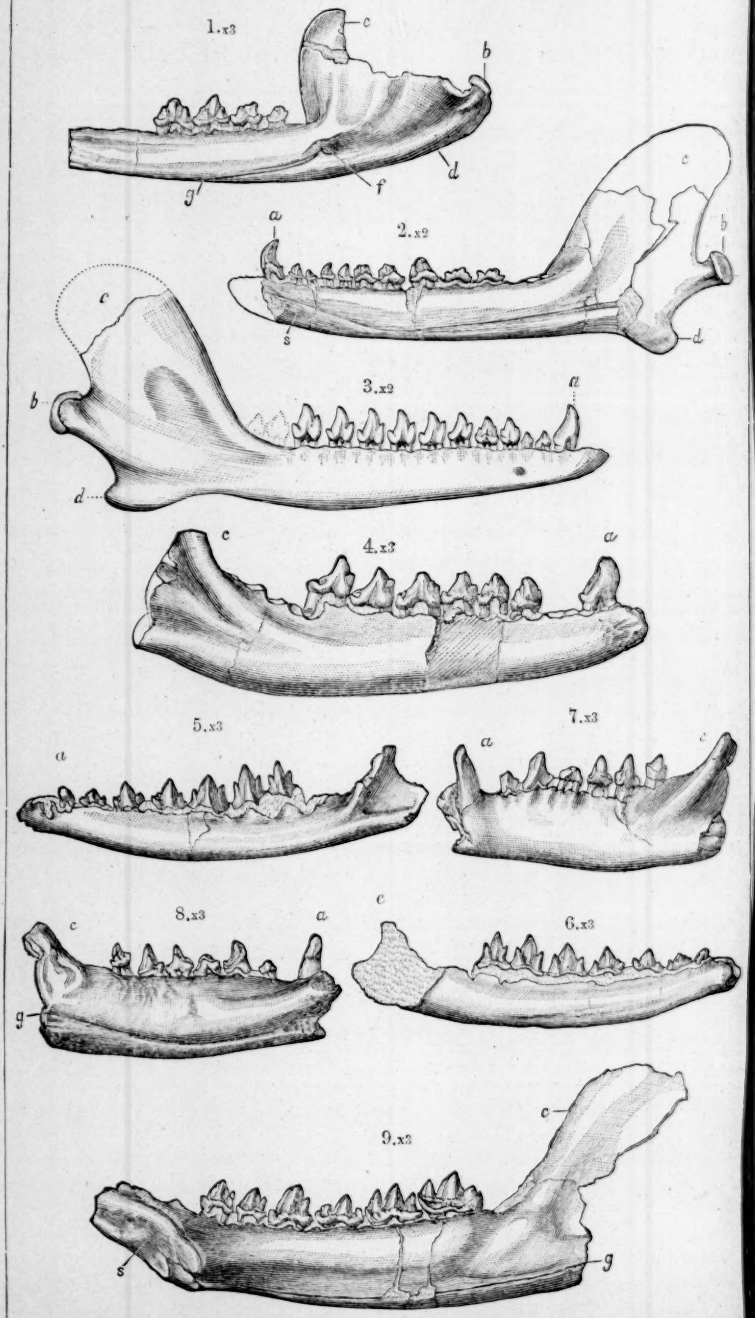
It was proposed to subdivide the Cyclostomata into two sections, namely:—1, those in which the surface of the zoarium is to a considerable extent formed of the lateral walls of the zoœcia, as *Entalophora*, etc.; and 2, those in which the zoœcia or cancelli open for the most part at right angles to the axis, or surface of the zoarium, or subcolony, of which *Heteropora* and *Lichenopora* are typical.

The author recorded the preservation of the extremely delicate and fragile rays or "hair-like teeth" in the interior of the fossil *Entalophora intricaria*.

Out of the twenty-eight species or varieties eighteen are known living, and this part of the collection agrees with the former in indicating that it is comparatively recent. The number of these fossil Bryozoa is now brought up to 106. The new species described by the author were:—*Entalophora wanganuiensis*, *Tubulipora tubipora*, *Lichenopora wanganuiensis*, *Reptocavea aspera*, *Heteropora napierensis*, and *Crassohornera waipukurensis*; and he also noted a new variety, *perangusta*, of *Diastopora sarniensis*.



AMERICAN JURASSIC MAMMALS.



AMERICAN JURASSIC MAMMALS.